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Science

A "Bivouac" of Army Ants in Panama

(See page 364)

FROM ORIGINAL 'ROCHE' RESEARCH....

B_1 — THIAMINE
1936 Isolation by 'Roche' on an industrial scale.
1937 New 'Roche' synthesis; production in kilos.
1939 Monthly production in hundreds of kilos.
1940 Monthly production by 'Roche' in tons.

NIACIN
1867 Prepared by Huber from nicotine.
1894 Amide synthesized.
1941 Quantity production to relieve shortage.

B_2 — RIBOFLAVIN
1933 Isolation from whey by Kuhn and co-workers.
1935 Synthesis by Karrer, 'Roche' collaborator.
1941 Industrial synthesis.
1942 Monthly production in hundreds of kilos.

L — ASCORBIC ACID
1934 Synthesis by Reichstein, 'Roche' collaborator.
1934 Pilot plant started.
1936 Large industrial production.
1942 'Roche' monthly production in tons.

B_6 — PYRIDOXINE
1938 Isolation completed.
1939 Work started on synthesis.
1941 Pilot plant production.
1943-45 Production increased to relieve shortage.
1946 Large-scale production.

E — α - tocopherol
1938 Synthesis by Karrer, 'Roche' collaborator.
1938-39 Synthesis and production of acetate.
1941 Acetate adopted as International Standard.
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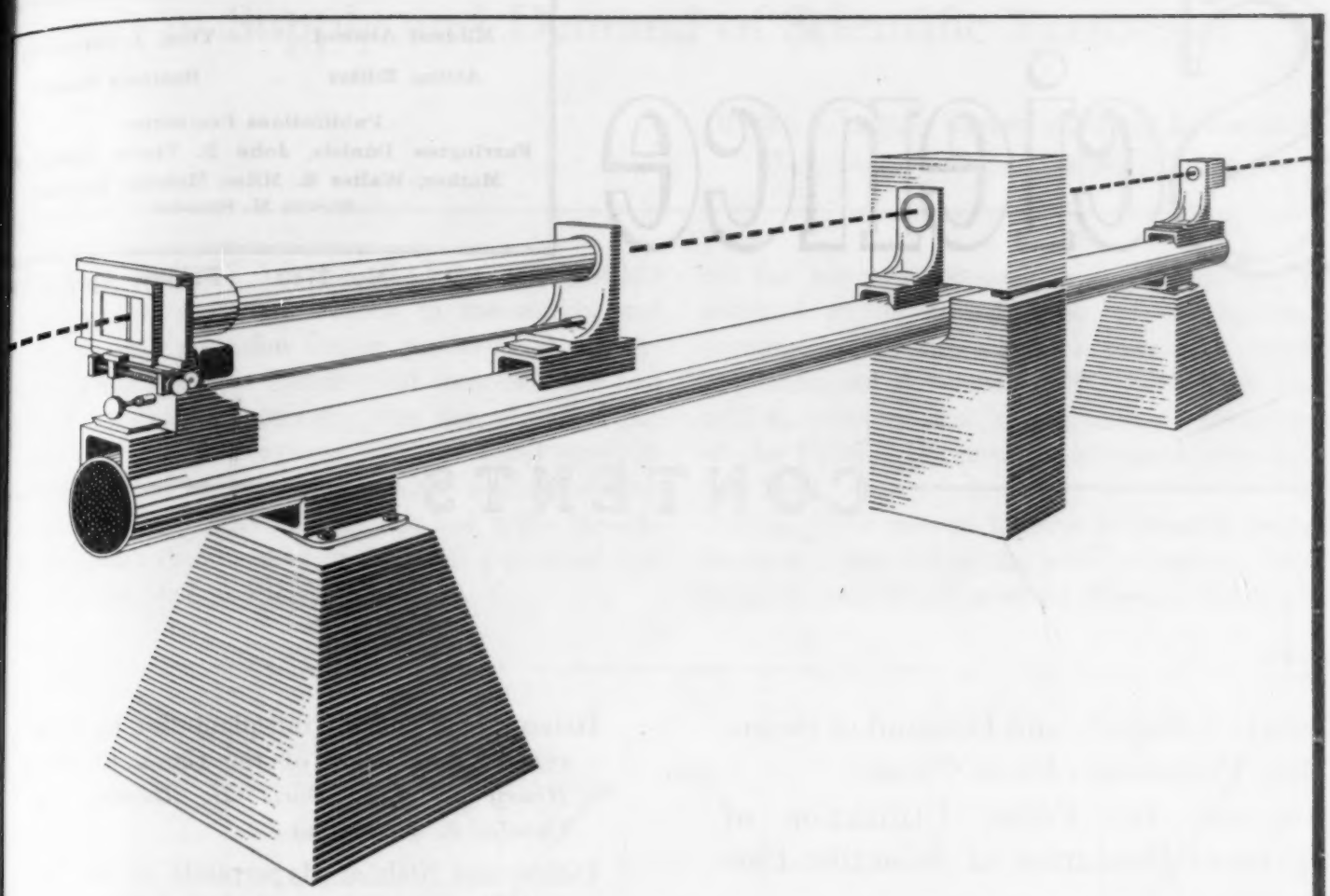

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Trends in Supply and Demand of Scientific Personnel

Ewan Clague, *Commissioner of Labor Statistics,*
U. S. Department of Labor, Washington, D. C.

THE PAST 7 YEARS HAVE WITNESSED a great surge of interest in the supply and demand situation among professional personnel. In the previous decade what interest there had been was caused by concern over the effects of the depression upon employment conditions and earnings of professional workers—the wastage and dissipation of skills. The recent interest has had quite the opposite focus: shortages of professional personnel and what can be done to alleviate them.

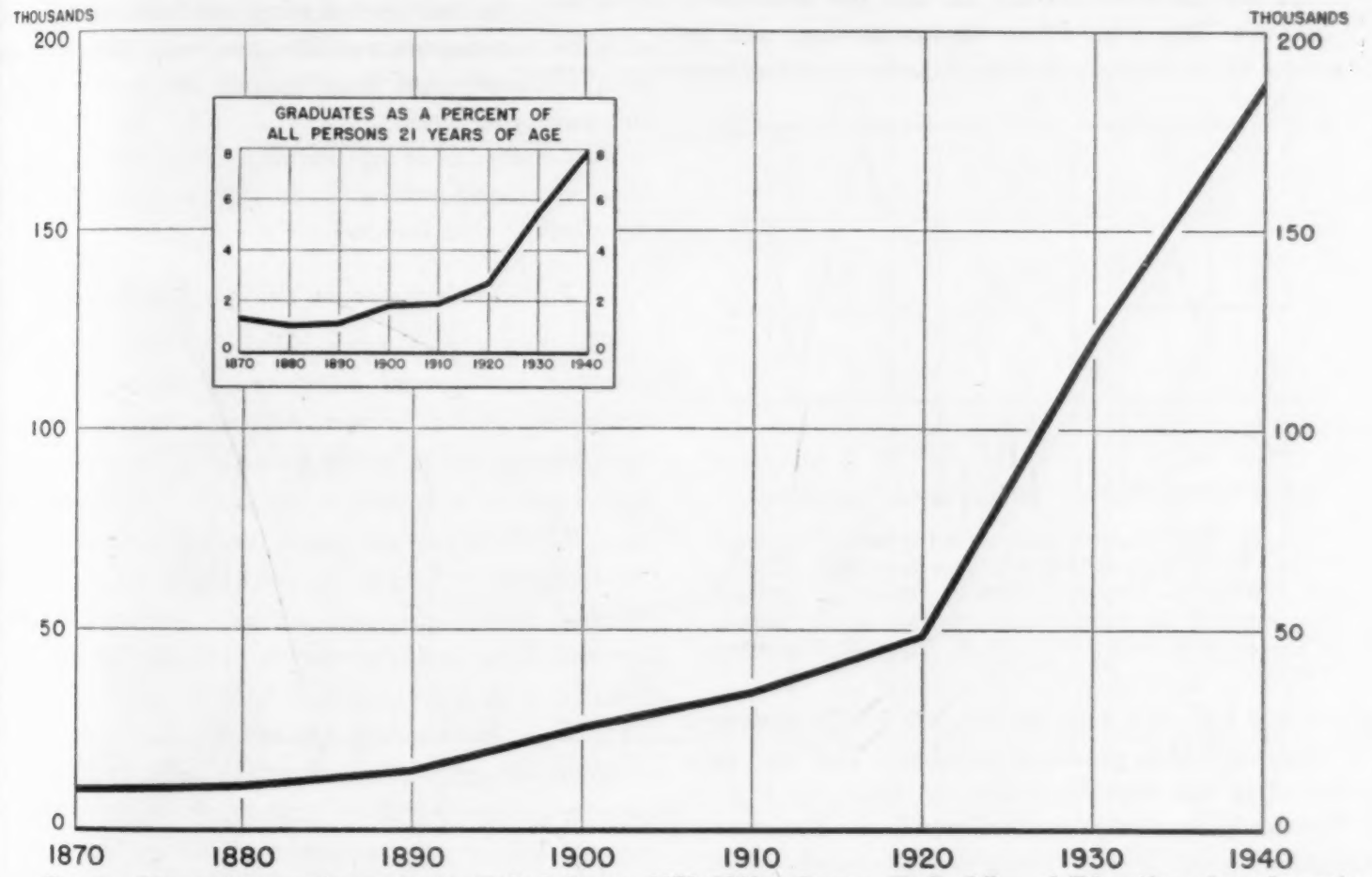

FIG. 1. New college graduates in the United States, 1870–1940. *Source:* U. S. Office of Education; baccalaureate and first professional degrees only.

This change of focus resulted first from such wartime problems as the need to expand research and development work (and other professional work) in industry and in the production programs of the armed forces, and to conserve our limited resources of scientific personnel, particularly with respect to Selective Service. In the postwar period, then, came tremendous new demands upon our scientific personnel for teaching, research, and development, as we achieved unprecedented levels of employment and business activity and a great expansion in enrollment in colleges and universities. Expenditures on research both in industry and by the military establishments of the Federal Government increased over the wartime level.

Finally, the current interest in scientific manpower has been intensified by the world situation. With the research resources of much of Western Europe all but destroyed, it becomes imperative that the United States take leadership in advancing the sciences. Furthermore, to those agencies on whom rests the responsibility for planning the national defense, the insuring of adequate scientific personnel resources in the future is a matter of great moment. Those who are trying to run a research program or a university department are painfully aware of the present shortage of trained workers in nearly every scientific field. The situation hampers scientific work seriously, and I look forward to Mr. Hausrath's discussion of ways

One of a series of four papers presented in a Symposium on Insuring Adequate Scientific Personnel Resources, held December 30, 1947, during the Chicago Meeting of the AAAS.

of meeting this problem. The question to which I shall address myself is the longer-range trend: What are the prospects that the shortage will be alleviated, that the supply will catch up with the needs?

Trends in Supply

If one generalizes from studies the Bureau of Labor Statistics has made of many occupational fields which reflect widely diverse professions and varying situations, certain broad trends become apparent.

Rising Long-Term Trend in Supply of Scientists

In virtually every professional field and most particularly in the scientific professions, the number of trainees has been steadily rising for the past several decades up to the recent war. This has reflected the increasing proportion of young people going to college. By and large, this trend went steadily forward through the prosperity of the '20s and the depression of the '30s (Fig. 1). It has meant not only steady increases in the number of college students and college

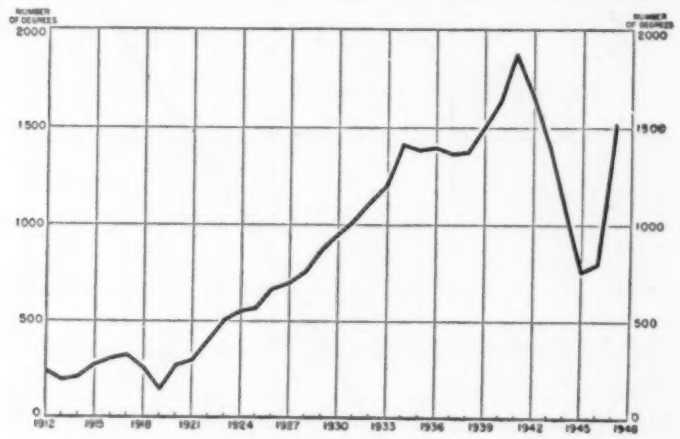

Fig. 2. Ph.D. degrees granted in the natural sciences in the United States, 1912–47. *Sources:* 1912–34, National Research Council; 1934–46, *Doctoral dissertations accepted by American universities,* H. W. Wilson Company, New York; 1947, U. S. Office of Education estimate.

graduates but also a great increase in the numbers of students taking graduate training. This has been reflected in the scientific fields, as shown by Fig. 2.

On the basis of this general trend, the President's Commission on Higher Education has recently estimated that college enrollments in 1960 would be something like twice their level in 1940 (or 2,900,000 as compared to 1,500,000). This Commission, however, has recommended that we strive to provide higher education for as many as 4,600,000 by 1960, or half again as many as would be expected on the basis of past trends.

If a National Science Foundation Bill should be enacted, a further stimulus will be given to the enrollment of students, particularly in the scientific fields, both by the scholarships which may be provided and by the interest which may be aroused by such Federal recognition of the importance of science.

The long-term increase in college enrollments was set back during the war, but has since received new impetus.

Wartime Losses in Training

In nearly every field there was great concern during the war about the impact of selective service upon scientists and potential scientists—the young scientists in industry, teachers in the colleges, and the graduate and undergraduate students. Its effect was most serious in 1945, when the number of Ph.D.s granted in the natural sciences dropped to less than half the 1941 peak (766 as compared to 1882), (Fig. 2). Actually, taking all the years we were at war—1942 to 1945—the number of Ph.D.s granted in science was only 23% less than in the previous 4-year period. The decline in total college graduates with the baccalaureate degree was somewhat greater. The emphasis in college training shifted sharply toward the natural sciences and the medical fields, so that their loss was proportionately less than that of the humanities or the social sciences.

This curtailment of training intensified the wartime shortages arising from increased demand, and its effect is still felt today.

Postwar Increase in College Enrollments

We may expect some relief, however, from the postwar increase in college enrollments. This increase represents, in part, delayed college attendance by veterans, but it is also a continuation of the long-term increase in college attendance. Enrollments are now 2,300,000 as compared to 1,500,000 in 1940. In nearly every field in the sciences, enrollments have reached new highs, and already graduations have surpassed all previous records in a number of fields. This is true, for example, of the number of Ph.D.s awarded in engineering, agriculture, and mathematics.

Moreover, enrollments by field indicate that even greater numbers will be graduating in the next few years. Taking *all* graduate studies together (including sciences and other fields), the number of *doctorate* degrees awarded in the last academic year was reported by the U. S. Office of Education to be 3,787—only 8% higher than the previously recorded peak of 3,537 in 1942. But the number of *master* degrees awarded last year was 35,919, or *one-third* higher than the previous recorded peak (26,731 in 1940). This suggests that we may have a further significant increase in the number of doctorates in the next year or two.

The impending rapid increase in supply of new workers is suggested by figures on training in chemistry—a field in which over half the doctoral degrees

in the physical sciences are granted—compiled by the U. S. Office of Education and the National Research Council. Just before the war 4,000–5,000 bachelor degrees were awarded annually, and a peak of 672 doctorates were awarded in 1941. Nearly half of those in the profession who had graduate degrees had received the doctorate, according to a survey of the Bureau of Labor Statistics. In the academic year ending in 1947 there were 6,009 candidates for graduate degrees, 7,652 seniors, and 9,963 juniors. It would appear that at the baccalaureate level we will soon have twice as many graduates as in the prewar peak year and, at the doctorate level, several times as many. In an occupation of perhaps 80,000 members, with a death and retirement rate of about 1,000 a year for the near future, the new supply in prospect would seem to represent a substantial addition, even though many chemistry students will go on to medical school or to high school teaching. This pattern is repeated in each of the major scientific fields.

Will the present wave of college students subside after a few years? In view of the past trends and the national goals set by the President's Commission on Higher Education it would seem clear that the current peak in college enrollments represents what may be a temporary upward bulge, but this bulge is on a rapidly rising long-term trend. Even if the wave should subside temporarily, a flood will be upon us after a few years. This points to the likelihood that the current shortage will be alleviated in all fields, and eliminated in some, within a few years. It raises the further possibility that in some fields we may even train more workers than we will have jobs for.

In no field has the postwar boom in college enrollment been more striking than in engineering—the largest scientific field of all, with its close to one-third of a million members. The interest of young men in this field, stimulated by the profession's dramatic contributions to winning the war and by widespread reports of shortages of engineers, has brought a deluge of students to engineering colleges. Including engineering students in liberal arts and junior colleges, current enrollments, estimated at close to 300,000, are more than three times the prewar average. In the 1920s about 7,000 men were graduated each year in engineering; in the 1930s, about 10,000; and in the present decade, despite the war, we shall average close to 20,000 graduates a year, hitting a peak of more than 45,000 in 1950 (Fig. 3). Deeply concerned with the implications of these figures, the American Society for Engineering Education has evaluated the potential demand for engineering graduates and has already pointed out the danger of oversupply in some engineering fields within a few years.

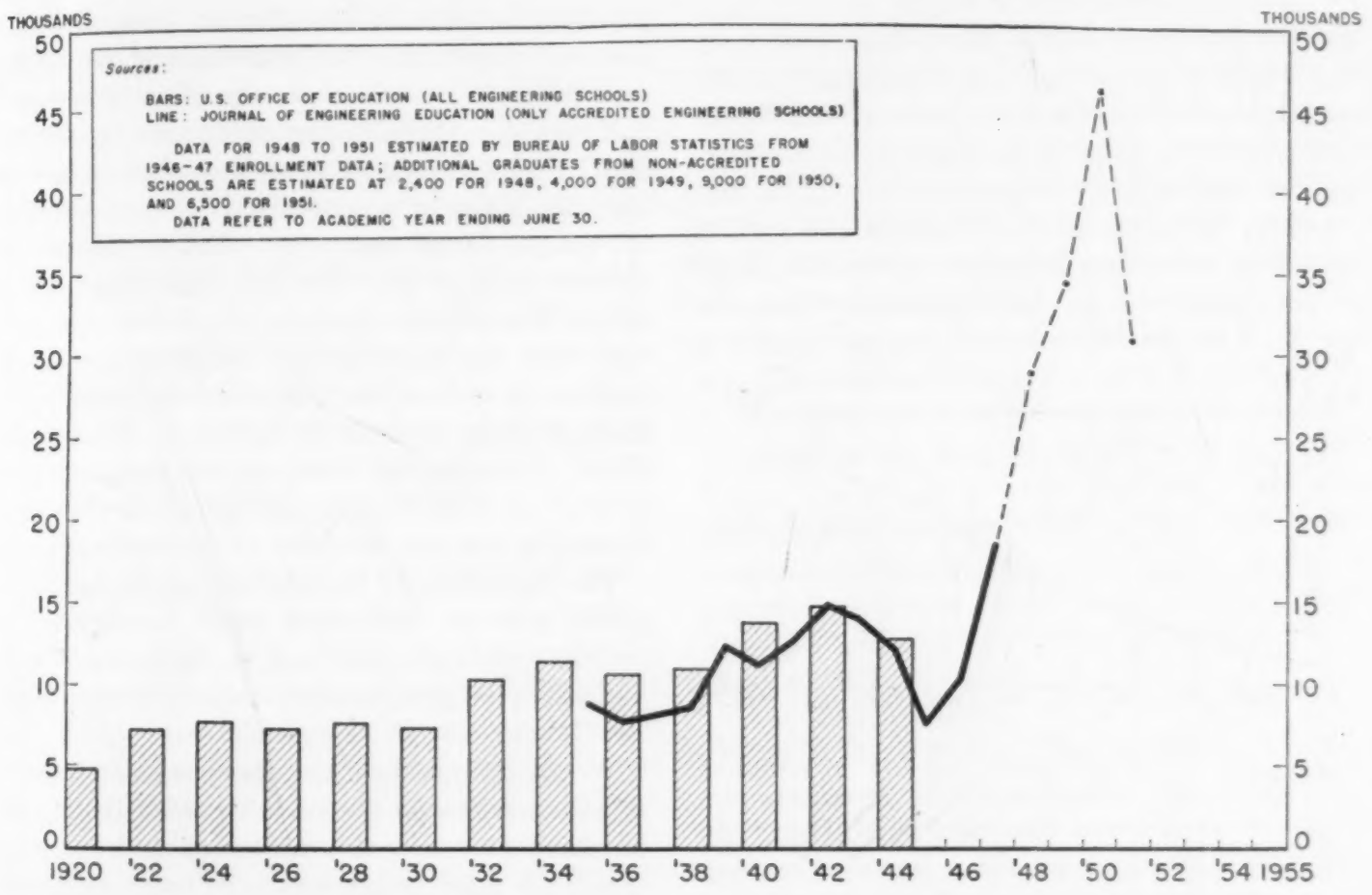
THOUSANDS
THOUSANDS
Sources:
BARS: U.S. OFFICE OF EDUCATION (ALL ENGINEERING SCHOOLS)
LINE: JOURNAL OF ENGINEERING EDUCATION (ONLY ACCREDITED ENGINEERING SCHOOLS)
DATA FOR 1948 TO 1951 ESTIMATED BY BUREAU OF LABOR STATISTICS FROM 1946-47 ENROLLMENT DATA; ADDITIONAL GRADUATES FROM NON-ACCREDITED SCHOOLS ARE ESTIMATED AT 2,400 FOR 1948, 4,000 FOR 1949, 9,000 FOR 1950, AND 6,500 FOR 1951.
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FIG. 3. Engineering graduates in the United States, 1920–51.

Looking at the data on enrollments in many other scientific fields, one may well raise the question: "Is this likely to be repeated in the other sciences?" To answer this question, analysis of the prospective needs for workers in each field and the toll of older scientists which will be taken by death or retirement is required. The experience of the engineers suggests the importance of careful study of the situation in other fields as well.

One thing seems clear from the trends in supply. Taking together the prospective growth in college attendance and the interest in science among young people, there would seem to be no lack of willing and able candidates for scientific professions.

Trends in Demand

The prospects for demand are not as clearly defined. There is no question that the long-term trend in employment of professional personnel, and particularly scientific workers, has been steadily upward. From less than 500,000 at the end of the Civil War the number of professional workers in the country increased to more than 3,000,000 before the recent war and continued to increase during the war (Fig. 4). At the beginning of the period shown,

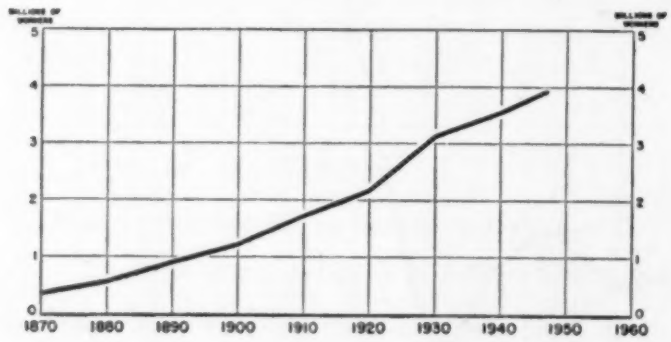

FIG. 4. Growth of professional and semiprofessional occupations, 1870–1947 (gainful workers, 1870–1930; labor force, 1940; civilian labor force, 1947). *Source:* Bureau of the Census; data adjusted by Bureau of Labor Statistics.

three-quarters of the professional persons were employed in four traditional vocations: teaching, the ministry, law, and medicine. Since that time, only teaching has kept pace in its growth with the 10-fold increase in the professions as a whole. Each of the other fields increased by only three or four times, and great new professions, like engineering, chemistry, and other scientific fields in which only a few thousand people were employed at the time of the Civil War, grew tremendously.

Studies the Bureau of Labor Statistics has made of the trends and outlook in most of the larger professional fields indicate that the trend in the growth of the professions should continue; in a recent report prepared for the President's Commission on Higher Education we suggested the possibility of a rise in employment to something like 5,000,000 by 1960 as compared to 3,333,000 in 1940 and just under 4,000,000 in 1947. The likelihood that the expansion foreseen in this study will be achieved—and possibly even exceeded—is increased by the goals the Nation may set for itself in the expansion of science (e.g. the Bush report, *Science, the endless frontier*; the National Science Foundation Bill; and the report of the President's Scientific Research Board, which urged that research expenditures be doubled to $2,000,000,000 a year by 1957), in the expansion of education (such as is recommended in the recent report of the President's Commission on Higher Education), and in the expansion of medical and health research and services. Thus, by and large, there is a great potential increase in the effective demand for professional personnel. The magnitude of the needs in each field can be estimated only after careful study, and even then the estimates are subject to wide error such as would result from such contingencies as, for example, a war or a depression. In the very nature of things, future needs in scientific research are difficult to evaluate. We can sometimes anticipate future demand for a group of skilled workers by observing the invention and introduction of a new machine or process that will affect their work. It is another thing entirely to anticipate the invention itself. The sciences, being at the forefront of the process of technological and economic change, are themselves not too amenable to forecasting.

The experience of the engineering profession suggests, however, that, until both the demand and supply trends are analyzed in each scientific field, we cannot be sure whether we are overtraining or not training enough new people.

We are all concerned that there be an ample supply of personnel to do the scientific work that needs to be done. We are also concerned that we do not encourage more young people to undertake training for scientific fields than the number for whom we can provide jobs. This would not only result in the loss of 4 to 7 precious years of a young man's life, but also would involve the cost to society of educating him. We in the Bureau of Labor Statistics are particularly aware of this problem, because vocational counselors and young people look to us for realistic information on employment prospects.

The training of more scientists than can be employed—if this is what is in prospect (*and we do not now know whether it is*)—would be serious enough if economic conditions should continue to be favorable, though its impact would be mitigated by the fact that it would be relatively easy for those who do not find employment in their chosen field to get

into other types of work. But what if we should have a recession or depression?

Remembering the status of the sciences and professions in the '30s, the low earnings, the wastage of the skills of highly trained people, the frustrations and bitterness that followed, we cannot but be impressed by the importance to scientific professions of the maintenance of generally high employment levels and favorable business conditions.

Implications

Some implications follow from the situation I have suggested—implications for the country as a whole, for the scientific professions, and for those doing vocational guidance work with veterans or young people in schools. In connection with this last group, I am particularly concerned with what we should say to those who are now just thinking of going to college and who would not come out for 5 or 6 years.

(1) *Quality of training.* If there should be a plentiful or overplentiful supply of candidates for scientific jobs, it will, of course, be easiest for those with the best training, the graduate degrees, etc. to obtain jobs. This will accelerate what is clearly observable as a long-term trend toward rising educational standards in the professions—a trend temporarily set back because of wartime shortages. Thus, our advice to the college student may well be to advance as high on the educational ladder as he can. This will be to the benefit of the profession as well as the individual.

(2) *Flexibility.* Because of the possibility that it may not be easy to find employment in some fields, a second point which we have often made in our advice to the individual student is emphasized. Studying occupational trends in many fields, as we do, we have become intensely aware of the uncertainty of economic trends affecting employment and have repeatedly expressed the desirability of maintaining one's occupational flexibility so as to be able to adapt to changing circumstances.

For scientific personnel, this means, in concrete terms, acquiring the broadest possible background in one's field and in related fields and avoiding the tendency to overspecialize. This recommendation, which we make on purely economic grounds, is forcefully reiterated on educational and social grounds in the recent report of the President's Commission on Higher Education.

It has been pointed out that the unemployed and underemployed professionals of the last depression constituted a reserve upon which we were able to draw when we needed to expand our professional employment rapidly during the war. When we count the cost of maintaining such a reserve in terms of personal frustration and the loss to other occupational fields—for example, the skilled trades—of men who might have made a successful adjustment there instead of being castaways on the doorstep of some profession, it seems to me that we cannot think in these terms in the planning of our scientific training program for the future. It is true that a war, if it should come, would require many more scientists than even the highest number we might expect on the basis of peacetime needs. I wonder if we might not seek an answer to this problem in the broadening of scientific education, even on the highest graduate levels, so that we will have an adaptable scientific staff who, with brief courses of intensified training (such as were given in the Engineering, Science, and Management War Training Program), can move from the field of their specialized experience to related fields in a short time. I do not know how feasible this may be and raise the point only as a suggestion for the consideration of this Association.

(3) *Balance among professions.* A third implication suggested by trends in the scientific fields is borne upon us vividly by studies we have made in other professional fields. I am raising the problem of proper balance among the professions.

During the war, college enrollments in the nonscientific fields suffered far more seriously than those in the sciences. This pattern has been repeated in the peak college enrollments of the postwar period. We all know that, with the engineering schools and the scientific faculties overburdened with tremendously increased enrollment, not enough students are preparing for the teaching profession—and this, despite the fact that there is a widely publicized shortage of teachers.

It has become commonplace to say that our advances in the humanities and in the social sciences are so far behind those in the natural sciences that our scientific achievements are placing tremendously destructive weapons into the hands of a society which, in moral, political, and social terms, has not progressed as far beyond the ape man as we sometimes like to think.

I will not labor this point, but will only add that the quantity and quality of teachers in the elementary and secondary schools is necessarily of great concern to the scientific professions. This is certainly underscored by the recent report prepared by the Cooperative Committee on the Teaching of Science and Mathematics, of the American Association for the Advancement of Science, for the use of the President's Scientific Research Board. This report pointed out deficiencies in the teaching of science and mathematics in the elementary and secondary schools which not only make it difficult for the potential scientist

to get a firm foundation in these subjects, but also—and perhaps more significantly—affect the ability of the public in general to think in scientific terms and to understand science. We need to improve teaching in the elementary and secondary schools, and this requires good teachers. The sciences cannot adequately serve their own ends or those of the Nation if too many young people are trained for scientific fields and not enough for other fields.

(4) *Guidance.* All this leads to the conclusion that there is need for the careful selection of candidates for all professions and occupations and careful guidance of all young people early in the educational process. While we cannot dictate to young people the choice of an occupation, we can certainly help them to make the best possible decision consonant with their interests, desires, and aptitudes in the light of the potential supply and demand situation in each occupation. Any help that the scientific professions, through their societies, can give to this endeavor will be a valuable contribution to the country and to the sciences.

Programs for Fuller Utilization of Present Resources of Scientific Personnel

A. H. Hausrath, *Director of Scientific Personnel, Office of Naval Research, Washington, D.C.*

WORLD WAR II MADE US KEENLY AWARE that America's need for certain resources far outstripped the national supply. Scientific personnel, by common consent, has been proclaimed as one of the most urgent of these shortages.

Enumeration of the present and probable future extent of the over-all shortages of scientific personnel is necessarily far from accurate, based as it is upon assumptions, opinions, piecemeal surveys, replicated counts, extrapolated estimates, fluctuating enrollments, and sheer guesses of future demand. Nevertheless, the unsaturated market for such personnel at present and the prospects for accelerated future demand emphasize the long-range wisdom and present urgency for full utilization of the talents of our human scientific resources.

The last few years have demonstrated the unprecedented returns that can be anticipated from a modest investment in research and development. Those who direct the activities of business and industry, as well as leaders in Federal and private efforts to advance the public welfare and to protect the national security, see clearly the promise of rich returns from the nurture of research. The research rush of 1947 appears to be ushering in a new era of scientific development.

Whether our national supply of scientific talent is numerous or scarce at any particular time, there will always be an insufficient supply of those on whose creative genius the world's progress depends. Full use of their rare talent is a prime responsibility of leaders of scientific activities. This paper reports in brief on some means of contributing to that goal. The thoughts and efforts which will be mentioned are the outgrowth of certain experiences in connection with the work of the Scientific Personnel Division of the Office of Naval Research. This Division was created two years ago—the first of its kind in a government agency—to assist in every appropriate way in improving the climate for research and development in the Naval laboratories, to cooperate with other Federal and private agencies in similar efforts, and to assure the Navy Department that it will be able to carry forward its scientific program with its fair share of an adequate national supply of thoroughly competent scientific personnel.

The research approach of the Division should be mentioned. This function is twofold: first, to see that each program of the Division is based upon as accurate facts as can be obtained by systematic investigation; second, to support research contracts with outside organizations to conduct studies which are basic to long-range planning and management of scientific personnel. For example, it was this Division which initiated by contract the roster activities of the National Research Council. It also initiated a contract with the American Council on Education to make a two-year study of cooperative arrangements with the country's colleges and universities for continuing graduate education for employed scientists.

While such research studies are in progress, the Office of Naval Research and its Scientific Personnel Division have been conducting a number of programs

One of a series of four papers presented in a Symposium on Insuring Adequate Scientific Personnel Resources, held December 30, 1947, during the Chicago Meeting of the AAAS.

to improve the scientific personnel situation, using the best data obtainable. Because some of these programs have widespread applicability, they will be described here. In general, they divide into two principal categories: (1) making the most of the present supply and (2) improving the supply.

Making the Most of the Present Supply

Self-imposed Restraint in Creating Expanded Demand for Scientific Personnel

Administrators are facing the cold facts of reality and are hesitating to embark upon extensive increases in facilities, not so much because of inflated building costs and scarcity and poor quality of available materials, but primarily because of the prospect of unavailability of personnel to operate these facilities once they are built.

One prominent dean of engineering, who is in touch with many industrial leaders, reports that the latter have contemplated expansions in their research and development programs which would require thousands of additional scientists. Because of their anticipated inability to staff new scientific laboratories, these leaders have curtailed their facility expansions so that their need for additional scientists can be counted in hundreds instead of thousands.

As an example of a self-imposed restraint on expanding demand, let me mention that the Office of Naval Research established a Facilities Review Board for the careful screening of all proposed projects which require new or additional facilities. The screening process involves consideration of the urgency of the project in relationship to the probable availability of personnel to staff the facility if and when it should be established. The Research and Development Board of the National Military Establishment and the Bureau of the Budget are also concerned with this problem for the military departments and the Federal Government as a whole.

It would seem desirable that every organization apply the same type of scrutiny to projects which will call for an expanded drain upon our present scientific manpower resources.

Full Employment of College and University Research Scientists on Research Work

While there is general agreement that the present total supply of trained scientific manpower is insufficient to conduct all the research and development that industry, government, and the universities desire to undertake, it must be recognized that manpower requirements for *development work* far exceed those for *research*.

This distinction is generally overlooked, although it strikes at the very core of the present manpower situation. Contrary to general belief, the research manpower resources of this country appear not to have reached their saturation point. Universities are seeking funds to support 50–100% increases in the number and total scope of basic research projects which they wish to pursue and for which they indicate, often by name, the trained researchers who are available for assignment to the proposed projects. While it is not known what the total research capacity of all our colleges and universities might be, even with their present staffs, the Office of Naval Research alone is supporting research projects which now employ 2,000 senior investigators and 2,500 graduate students. At present these projects are scattered among various departments in approximately 150 universities. Judging by the research proposals submitted from these and other colleges and universities on their own initiative, it is evident that they can more than double their present research efforts, measured in terms of the present volume of Office of Naval Research contracts.

In addition, there are large numbers of other institutions with laboratory facilities and with thousands of staff members who are competent research workers but who are not now engaged in research work because their institutional budgets are overstrained to care for the greatly increased undergraduate student load. In attempting to meet the increased demand for teachers, primarily at the undergraduate level, it is probable that many excellent research investigators are being impressed into service as teachers of undergraduate classes, an assignment for which they may be less well suited. We must meet the teacher shortage, but this does not seem to be the best use of research workers.

Restraint in the Preoccupation of Research Scientists on Development Projects

One trend with serious implications is the submergence of research work in favor of developmental and engineering assignments. While the pressures are of different intensities in industry, government, and universities, all are exposed to the financial attractiveness of utilitarian projects.

With a shortage of scientists and engineers to man the full quota of desired developmental work, developmental projects which *can be* postponed without too serious impact upon our welfare and economy should be, thereby freeing research scientists to work on fundamental studies. Even though their results cannot be premeditated, research studies are, in a very real sense, the more important immediate need.

Increased Use of Advanced Scientists as Consultants

No matter how abundant our supply of thoroughly trained scientific personnel may become, there never will be an oversupply of the most fertile and creative minds. Nature, economic opportunity, and individual drive combine to produce a small share of the genius required to cope with the ever-expanding complexity of problems.

Full utilization of our most highly developed scientific talent is more than an idealistic dream—it is a national necessity. We have learned some techniques that contribute to this goal. Among these is the wider use of persons with the most advanced knowledge as consultants to those who will carry programs into action. Consultative service of this type is being employed on specific projects in a variety of ways, including regularly organized advisory committees, special conferences, *ad hoc* panels, individual consultants, and private consulting firms. By using part-time consultants, the ability of a few can be spread to serve many needs. It is a method for multiplying our scarcest resource of all—the highest level of scientific competence. Full-time scientific consultants are being employed more and more within the Navy's scientific program, e.g. the deputy and chief scientist of the Office of Naval Research. Such an arrangement permits the consultant to be used on scientific problems exclusively, free from the drain on his time for the inevitable multiplicity of nonscientific duties which befall one who bears the responsibility of administration.

Reduction of Nonscientific Duties of Scientists

Where the scientist must also be the administrator, we are finding his administrative load can be shared by special administrative assistants who can follow through on the nonscientific aspects of his duties. Without this type of assistance, the administrator would have little or no time for exercise of his scientific knowledge. Too often scientists have lost their competence and eminence as scientists because of the usurping urgency of administrative duties when they have been placed in administrative positions in scientific activities. This is unfortunate for science, the laboratory, and the scientist himself.

Reduction of Low-Level Scientific Duties of Advanced Scientists

The wider use of laboratory assistants and aides to do more routine scientific tasks and adequate clerical, secretarial, and statistical assistance also enable the scientific staff members to devote a higher proportion of their time to work commensurate with their abilities. For example, the 1,000 professional scientists and engineers at the Naval Research Laboratory are supported in their work by 2,000 subprofessional, clerical, administrative, mechanic, and custodial employees.

Fluid Assignments of Scientists to Projects and Research Teams

Another device, which we are presently studying, is a suitable organization and structural pattern of a scientific laboratory to facilitate the most productive and fluid team groupings of research workers. This concept presupposes that each research study or project would suggest its own needs for participation of scientists from various fields of specialization as the problems unfold. At present some research activities are not structurally flexible enough to adapt to ever-changing, unforeseen leads.

Somewhat similar to the last device is the possibility of doing a better management job of classifying the skills and competences needed to carry through a complex scientific program and breaking down the tasks to be performed so that each scientist would be working at his own full level of competence most of the time. It is much more difficult to organize a scientific laboratory to use lesser-skilled workers on lower-skilled tasks, in such a manner as factory production lines are planned. But it may not be entirely impossible.

Facilitation of Placement for Full Employment of Talents

Another waste of scientific talent occurs when a scientist is employed at a laboratory which cannot fully use his special talents. This can occur as the result of, for example, change in the work of the laboratory, professional development of the scientist beyond the tasks for which he was employed, a poor choice of position in the first place, or a change in personal fortunes. Whatever the cause, the Office of Naval Research has found it possible to reduce the number of original errors of this type, and correct misplacements that develop after the scientist enters upon the job, by operating a Navy-wide, central clearinghouse which lists the current scientific personnel needs of all laboratories and refers scientists to those laboratories most likely to need their special skills.

Improving the Supply

Over and beyond the responsibilities of educational institutions in any large-scale, long-term effort to improve the supply of scientific personnel are opportunities for the industrial and governmental agencies to assume more direct responsibility for the professional improvement of scientists already in their employ.

University-Credit Courses for Employed Scientists

University-credit courses for employed workers is not a new idea. For many years educational institu-

tions in metropolitan areas have been offering courses in the late afternoon and evening for employed workers. But a new approach to this plan has recently demonstrated its vitality. After the Japanese surrender Federal agencies were cut back to the normal 40-hour work week. The Navy laboratories and bureaus seized upon the opportunity this shorter week offered to encourage their civilian scientists to enroll in university courses leading toward advanced degrees.

In the Washington area alone some 41 courses with nearly 1,000 students are now in progress at the Naval Research Laboratory, the Naval Ordnance Laboratory, the David Taylor Model Basin, the Naval Gun Factory, and the bureaus of the Navy in cooperation with the University of Maryland and the U. S. Department of Agriculture Graduate School. Students register and pay the regular fees at the university and obtain university credit upon satisfactory completion of courses. Some of these courses are given at the educational institutions, but many are given in the laboratories themselves. A considerable number of the instructors are naval scientists with teaching experience, officially designated as members of the university faculties offering these courses. The great majority of the present courses are at the graduate level. At other naval laboratories and establishments throughout the country, another 500 scientists, engineers, and technicians are enrolled.

Similar arrangements are under way in Army, Air Forces, and other Federal laboratories.

Another interesting and valuable opportunity offered to Navy civilian scientists at several naval establishments is "thesis accrediting." Arrangements have been made with a number of leading universities whereby a man who has completed all his residence and course work requirements and passed his preliminary examination for a Ph.D. may use the research he is carrying on at the laboratory as a basis for his thesis.

These programs require careful planning, careful selection of students and instructors, and close integration with the university programs to insure the highest academic and professional standards.

In-Service Training

In addition to the university-credit courses previously discussed, many industrial and Federal agencies have sponsored noncredit in-service training to help their engineers and scientists become proficient in the special and advanced phases of their professional fields, especially as they relate to their assigned duties. For a long time the National Bureau of Standards has been offering each year a small number of graduate level, noncredit courses taught by their own senior scientists. The U. S. Department of Agriculture has had its own non–degree-granting Graduate School for many years. The Navy sponsors similar courses which are sometimes restricted to scientists of the military establishment and sometimes open to scientists from other Federal or private organizations. These courses range through a wide variety of types, including systematic and comprehensive study of certain special subjects, lecture courses on recent developments, seminars, colloquia, symposia, conferences, and other forms as appropriate to the need. They also range from a single session to a year and a half in length.

Training of Personnel for Undersupplied Fields

The Department of the Navy is actively assisting universities in the development of facilities for research and instruction in fields that require highly specialized equipment not otherwise available to the institution. In this manner a large number of graduates are being prepared for work in certain shortage fields. Such assistance has been given in the fields of electronics, nuclear physics, mathematical computers, aerodynamics, hydrodynamics, oceanography, meteorology, and cosmic rays, to name only a few.

Special Curricula

The Office of Naval Research is encouraging the offering of special curricula in universities to increase the availability of trained workers in certain new and undersupplied fields, such as machine computation.

Opportunities Offered by Research Contracts

Finally, the Office of Naval Research is placing basic research contracts at universities where the contract provides a dual benefit. Not only is the research study carried forward with new knowledge available to all scientists, but, equally important, the project provides the opportunity to train an oncoming supply of research workers. The 700 ONR-sponsored research projects now under investigation at approximately 150 universities throughout the country provide direct research training for 2,500 graduate students.

The programs reported here illustrate that there are a number of ways in which more, and perhaps better, scientific work can be done with the number of scientists and engineers available at any one time. It is hoped that this discussion will stimulate other organizations to adopt similar methods and to develop new and better means of making the most effective use of this country's scientific talent.

NEWS and Notes

The first live colony of the marauding, carnivorous army ants ever brought to this country from the tropics arrived last month at the American Museum of Natural History, New York, in care of members of an unusual expedition which has spent the past 5 months on Barro Colorado Island, Panama, and in the Darien district studying these most predatory of ants. Upon the return of the group, T. C. Schneirla, its leader, stated that the field work had disclosed considerable new information on the formation of the huge queen ants. For example, the group's observations indicate that only one of many army ant broods each year produces queen ants. This brood, which is the smallest (3,000 as opposed to other broods which number up to 30,000), is in large part male. New queens are produced from the very small number of females born in the brood. Dr. Schneirla also voiced the probability that prospective queens possess a chemical attraction for other ants in the colony, this attraction resulting in a swarming of workers around young larvae of new queens and an increase in food supply. Further, the colony queen produces, at regular times during the year, a brood of some 25,000 workers.

The army ants move in columns which sometimes exceed 300 yards in length. This they do nightly for about 17 consecutive nights, after which the colony stops for 20 days. In addition to their raids on the insect life of the jungle, the ants occasionally attack snakes and small mammals.

This week's cover shows a temporary nest (or "bivouac") of the swarm-raiding *Ecitron burchelli*. These bivouacs are formed of the clustered bodies of the worker ants themselves and consist essentially of a more compact outer wall and a looser internal structure. The single queen and inevitable brood are located at or near the center of the ant mass. The colony pictured was estimated to contain at least 250,000 workers. Also present in this particular colony were a newly emerged brood of about 3,000 alate males, a large brood of young worker larvae, and two queens, one a single "old" colony queen, the other a young queen which later on formed the basis for a colony division.

The recent field studies conducted by Dr. Schneirla, Ernest Enzmann, research associate in zoology at Massachusetts Institute of Technology, and Robert Z. Brown, student in zoology at Swarthmore College, are part of a continuing program designed to investigate the organic basis of behavior. The general scientific research program is being conducted by the Museum in cooperation with the American Philosophical Society, the National Research Council, and the Office of Naval Research.

About People

S. A. Goudsmit, former professor of physics at Northwestern University, is now with the Brookhaven National Laboratory in the Theoretical Physics Division. During the war Dr. Goudsmit led a group of civilian investigators on the Alsos mission to Europe. The story of the mission is told in *Alsos* (Schumann, 1947), of which he was the author.

Francis W. Sears, professor of physics at Massachusetts Institute of Technology, has been named to head a group working on the development of national standards in the field of optics, according to a recent release from the American Standards Association. The committee's work will include "formulation of terminology, definitions, standards, and specifications in the general field of optics and the establishment of methods of testing, rating, and classifying the performance characteristics of materials and devices used in optics, including the methods for the specification and description of color and also including the psychophysics of vision."

William E. Colwell, professor of agronomy and director of the tobacco research program at North Carolina State College, has been appointed head of the College's Department of Agronomy. He succeeds **Ralph W. Cummings,** new associate director of the Experiment Station.

Esmond R. Long and **Walsh McDermott** have been named editor-in-chief and managing editor, respectively, of *The American Review of Tuberculosis,* official journal of the National Tuberculosis Association's medical section, the American Trudeau Society. The appointments were effective April 1. Dr. Long, director of the Henry Phipps Institute, Philadelphia, and director of NTA's medical research and therapy since January 1947, succeeds the late Max Pinner. Since Dr. Pinner's death Chesley Bush, of Livermore, California, has served as interim editor. The managing editorship, to which Dr. McDermott, associate professor of medicine at Cornell University Medical School, has been appointed, has recently been created.

A. Q. Sartain, professor and chairman of the Department of Psychology, Southern Methodist University, has also been named chairman of a newly organized Department of Personnel Administration in the School of Business Administration.

Stuart B. LeCompte, formerly research engineer with the Hartford-Empire Company, Hartford, Connecticut, was appointel associate professor and associate research specialist in horticulture, New Jersey Agricultural Experiment Station, last November 1. He fills a vacancy left by **V. A. Tiedjens,** now director of the Virginia Truck Experiment Station, Norfolk.

Percy L. Ricker, widely known in agricultural research as a taxonomic botanist, retired from the U. S. Department of Agriculture March 31 after more than 46 years of govern-

ment service. Throughout his career he has been interested in the conservation of wildflowers and has headed the Wildflower Preservation Society since 1925.

Charles L. Spurr and **Gilbert H. Fletcher** have joined the staff of the M. D. Anderson Hospital for Cancer Research of the University of Texas. Dr. Spurr, who was formerly assistant professor of medicine at the University of Chicago, will serve as internist and director of the clinic, and Dr. Fletcher, who has been a traveling fellow for the Hospital observing methods of radiation therapy in Europe, will serve as radiotherapist.

Edwin A. Phillips, instructor in botany at Colgate University for the last two years, has been appointed assistant professor of botany at Pomona College. Mr. Phillips, whose special field is the physiological ecology of bryophytes, will receive his Ph.D. from Michigan in June.

Stuart W. Smith, formerly of Walter Reed General Hospital, Washington, D. C., has been appointed instructor in the Department of Anatomy, University of Colorado Medical School.

C. R. Hamilton has become a member of the engineering faculty of the New Mexico School of Mines at Socorro. For the past few years Dr. Hamilton has been associated with the School's Research and Development Division in Albuquerque.

Brooks F. Smith has been named assistant chief of the Test Division, Chemical Corps Technical Command, Army Chemical Center, Maryland, and **George H. Milly** has been appointed chief of the Planning and Evaluation Branch, a recently established unit of the Test Division.

Visitors to U.S.

Mme. Irene Joliot-Curie, wife of Frederic Joliot-Curie and co-winner with him of the Nobel Prize in chemistry in 1935, has returned to France. Mme. Joliot-Curie arrived in the United States on March 18 on a 15-day visitor's visa "to acquaint the American people with the immediate needs of the Spanish Republic in exile."

The Harvard School of Public Health announces that William N. Pickles, Medical Officer of Health, Aysgarth Rural District, Yorkshire, England, will deliver the Cutter Lecture on Preventive Medicine at the Harvard Medical School (Amphitheatre D) on April 12, 1948, at 5:00 P.M. Dr. Pickles has chosen as his subject "Epidemiology in Country Practice."

Walter Heitler, physicist of the Dublin Institute for Advanced Studies, will be visiting professor in the Physics Department, Columbia University, during the spring semester.

Colleges and Universities

A new $142,000 laboratory for vacuum tube research was opened last week at the University of Illinois. Tube research, which is an important part of the University's $500,000-a-year program in the electrical engineering field, will be greatly facilitated in the new laboratory, which is designed to insure a steady, economical flow of parts from the grinding room to the testing laboratory. At present there are 5 individual projects under way, attention being focused on the study, perfection, and production of microwave tubes of the klystron, magnetron, and traveling wave types. In addition to A. L. Samuel, director of the projects, and J. T. Tykociner, who pioneered the study of antenna models and ultra-high frequency transmitters, the research staff includes 8 design engineers, 23 fabrication and assembly employees, 4 instrument makers, and 3 secretaries.

"The Strategy of the Social Sciences" will be the topic of the April meeting of the Graduate Forum at Harvard University. The program, which will feature as speakers P. W. Bridgman, Hollis professor of mathematics and natural philosophy and Nobel Prize winner in physics, and Samuel A. Stouffer, professor of sociology and director of the Social Relations Laboratory, is scheduled to begin at 8:00 P.M. on April 20 in the New Lecture Hall of the University. Dr. Conant will act as chairman for the evening. Tickets may be obtained for $.50 by writing to the Graduate Forum, 87 Perkins Hall, Harvard University, enclosing a self-addressed, stamped envelope.

The Pacific Marine Station of Biological Science, located at Dillon Beach, Marin County, California, has recently added two buildings with approximately 10,000 square feet of floor space and including 14 well-equipped laboratories and has begun year-round operations as a research and educational institution. The station is under the direction of Alden E. Noble, of the College of the Pacific. At Dillon Beach there exists a remarkable variety of marine habitats, with consequent abundance and diversity of living things.

Illinois Institute of Technology's annual Open House is scheduled for April 21–22. On these two days the public will have an opportunity to view demonstrations, exhibits, and displays covering technological, scientific, and engineering research projects and educational facilities of the Institute. In addition, there will be guided tours through the industrial research laboratories of the Armour Research Foundation. Included among the wide variety of interesting demonstrations will be magnetic wire recording, production of liquid fuel from coal, petroleum cracking processes, the making of snow and rain, and electronic cooking.

Summer Programs

Harvard University's Summer School is featuring a two-day forum on "Ways to Mental Health," July 21–22. At that time 7 authorities on human behavior—psychiatrists, psychologists, sociologists, and anthropologists—will present the theories and practices of their respective professions. A maximum of participation by laymen and the public will be allowed. Sponsored jointly by the Harvard Summer School and the Massachusetts Society for Mental Hygiene, the conference will be open to summer school students and members of the Society without charge; a small registration fee will be required of others wishing to attend. Those representing the field of psychiatry include H. C. Solomon, professor of psychiatry at Harvard and director of the Boston

Psychopathic Hospital; R. H. Felix, chief, Division of Mental Health, U. S. Public Health Service; L. S. Kubie, associate in neurology, College of Physicians and Surgeons; and K. A. Menninger, president of the Menninger Foundation. The social aspects of the problem will be presented by Clyde Kluckhohn, professor of anthropology at Harvard, and E. W. Burgess, professor of sociology, University of Chicago. Carl Rogers, of the University of Chicago, will represent clinical psychology. Talcott Parsons, professor of sociology at Harvard, is chairman of the committee which organized the conference.

Industrial Laboratories

Allied Chemical & Dye Corporation, continuing for the school year 1948–49 the graduate fellowship plan established by it some years ago, announces that a total of 30 graduate fellowships, mainly in chemistry and chemical engineering, have been offered to 23 universities, colleges, and institutes of technology. The company considers that these fellowships, by furthering advanced research training, aid in increasing the country's research potential. As heretofore, the recipients of the awards, and the type of research to be conducted, are selected by the schools. Each fellowship provides a stipend of $1,200 and tuition.

Schools offered such fellowships for 1948–49 are: California, Carnegie, and Massachusetts Institutes of Technology; the Universities of California, Illinois, Iowa, Michigan, Minnesota, Pennsylvania, and Wisconsin; Columbia, Cornell, Duke, Harvard, McGill, Northwestern, Ohio State, Princeton, Purdue, Syracuse, and Yale Universities; Pennsylvania State College; and Polytechnic Institute of Brooklyn.

A limited quantity of pure estrone sulfate, labeled with radioactive sulfur (S^{35}), is to be distributed free of charge by Ayerst, McKenna & Harrison, Ltd., for investigation of the metabolism of female sex hormones. Prepared from radioactive sulfur supplied by the Atomic Energy Commission, the tagged hormone will exhibit approximately one millicurie of activity per millimol of compound. Complete and detailed information will be provided for the samples distributed. Private physicians, clinical groups, and teaching institutions interested in participating in this program of research should send a brief outline of the type of study proposed, a list and brief background of the investigators who will be concerned, and a statement of the quantity required to V. Johnson, Medical Department, Ayerst, McKenna & Harrison, Ltd., 22 East 40th Street, New York 16. Studies on all phases of the subject of estrogenic activity will be considered. Applications will be received until September 1, 1948. Upon notification those selected to receive this material should secure the necessary approval from the Isotopes Division of the AEC by October 1, 1948. It is expected that the samples will be distributed in January 1949.

Elliott R. Weyer, former associate director, Division of Patent Management, Research Corporation, has joined the scientific staff of Chas. Pfizer & Co., Brooklyn, New York.

Herbert J. Spoor, biochemist, has been appointed assistant director of the Medical Division of Bristol-Myers Company, New York. Dr. Spoor holds both the Ph.D. degree in biochemistry (Ohio State, 1940) and the M.D. degree (New York University, 1945). For the past three years he has been serving as a captain in the Army Medical Corps.

Harris L. Friedman, formerly director of the Division of Pure Research, Pyridium Corporation, is now chief of the Chemistry Division, Lakeside Laboratories, Milwaukee, Wisconsin.

Harold A. Clymer, who has been associated with Smith, Kline & French Laboratories, Philadelphia, as a pharmaceutical chemist since 1939, has recently been appointed administrator of the Research Laboratories.

John H. Kelly, Jr., has resigned as research director of the General Tire and Rubber Company's mechanical goods division at Wabash, Indiana, effective April 15, in order to head three manufacturing activities being organized locally.

Laurence A. Hawkins on March 31 ended 36 years of service in the General Electric Research Laboratories and 45 years with the Company. Although he retired from his position as executive engineer of the laboratory in March 1945, he has continued as a consultant for the past three years.

Meetings and Elections

The New York State Geological Association is holding its annual field conference April 30–May 1 at Hamilton College, Clinton, New York, with instructional staffs and students from the principal New York colleges and universities attending. These annual conferences are held by the Association for the purpose of aquainting students with New York geology and promoting friendship between geological faculty and students in the various educational institutions of the state.

The Annual Foray of the Mycological Society of America will be held June 15–17 at the Biological Station of the University of Michigan, near Cheboygan, according to an announcement just received from Joseph C. Gilman, secretary-treasurer. There are numerous bogs and coniferous and hardwood associations in the region, and the mycological flora should be unusually interesting. There will be laboratory accommodations, and board and room will be provided at about $3.00 per day per person. No reservations may be made after June 10. Those interested in participating should contact F. K. Sparrow, University of Michigan, Ann Arbor, for further information.

The Laurentian Hormone Conference of the AAAS will meet this year at the Forest Hills Hotel, Franconia, New Hampshire. The dates are September 13 to 18, inclusive. The program, to be published in full at a later date, will consist of four sections: I, The metabolism of steroid hormones *in vivo* and *in vitro;* II, Thyroid physiology and function; III, The role of hormones in tissue and body metabolism; and IV, Hypothalamic neurohumoral relationships.

Because of limited accommodations, attendance is by invitation, but the Committee on Arrangements will re-

ceive applications for membership until June 15. Such applications should be addressed to: Dr. Gregory Pincus, Chairman, Committee on Arrangements, 222 Maple Avenue, Shrewsbury, Massachusetts.

The Hodgkin's Disease Research Foundation, Inc., at its recent meeting in New York, elected the following officers for the current year: Herman Hoster, Ohio State University, president; Antonio Rottino, St. Vincent's Hospital, New York City, first vice-president; John F. X. Finn, Fordham University, second vice-president; and Harry A. Rolnick, of Philadelphia, secretary-treasurer. The Foundation's offices are at 7th Avenue and 11th Street, New York 11, New York.

Joe Young West, director of the Science Division, State Teachers College, Towson, Maryland, and a member of the summer school faculty, University of Maryland, has been elected president of the National Association for Research in Science Teaching for 1948–49.

NRC News

A new program of fellowships supported by funds provided by the Atomic Energy Commission as a part of the Commission's responsibility for future atomic energy research (*Science*, February 6, p. 136; March 5, p. 241) has just been announced by the National Research Council. Accordingly, these fellowships will be awarded in the many fields of science related to research in atomic energy.

A considerable number of these fellowships are available to young men and women who wish to continue in graduate training or research for the doctorate in an appropriate field of science. Others will provide training in biophysics applied to the control of radiation hazards. An additional number of fellowships will be assigned to those below the age of 35 who have already achieved the doctorate and who wish to secure advanced research training and experience in those aspects of the physical, biological, and medical sciences related to atomic energy. Tenure of the fellowship does not impose on the fellow any commitment with regard to subsequent employment.

The candidates will be selected by NRC fellowship boards established for this program. In the postdoctoral field, there will be three groups of fellowships, the basic stipend of which will be $3,000. For the selection of fellows for advanced research and training in the general field of the physical sciences, a board has been established with Roger Adams, professor of chemistry, University of Illinois, as chairman; in the general field of the biological sciences, exclusive of the medical sciences, selections of postdoctoral fellows will be made by a board under the chairmanship of R. G. Gustavson, chancellor of the University of Nebraska; and postdoctoral fellows in the medical sciences will be selected by a board which has been set up under the chairmanship of Homer W. Smith, professor of physiology, College of Medicine, New York University.

The program provides for two groups of fellows in the predoctoral field, with stipends ranging from $1,500 to $2,100. One group of fellows will work in the biological and basic medical sciences, including applied biophysics, related to the measurement and control of radiation hazards and the effect of radiation upon health. Selections will be made by a board under the chairmanship of Douglas Whitaker, professor of biology and dean of the School of Biological Sciences, Stanford University. Another group of predoctoral fellows will be selected for study and research in the general field of the physical sciences. These selections will be made by a board under the chairmanship of Henry A. Barton, director of the American Institute of Physics.

Fellowships will be granted for study and research in universities or other nonprofit research establishments approved by the fellowship boards. Awards will be made for the academic year 1948–49. Supervision of a fellow's program of work will be under the direction of the NRC fellowship boards. Further information can be secured by writing to the Fellowship Office, National Research Council, 2101 Constitution Avenue, Washington 25, D. C.

Deaths

A. B. Turner, 75, professor emeritus of mathematics at the College of the City of New York, died February 5.

G. E. Wahlin, 67, professor of mathematics at the University of Missouri, died February 11.

William H. Davis, 71, retired professor of mycology and plant pathology, University of Massachusetts, died March 19 in Northampton, Massachusetts.

Richard B. Feibelmann, 64, research chemist in the Aktivin Corporation, a subsidiary of the Heyden Chemical Corporation, died March 25 in Port Jervis, New York.

Thomas M. Snyder, 54, ophthalmologist and professor of histology and embryology at Hahnemann Medical College, died March 25 in Philadelphia.

C. D. Jarvis, 72, former director of agricultural training in the U. S. Bureau of Education, died March 27 in Grimsby, Ontario.

A. te Weckel, 67, professor of forestry at the Agricultural University, Wageningen, The Netherlands, died March 28.

The first agricultural study to be financed by the Atomic Energy Commission will soon be initiated by the Bureau of Plant Industry, Soils, and Agricultural Engineering of the Department of Agriculture. A number of agricultural experiment stations will cooperate with the Bureau in the new project, which is aimed at finding facts about the effects of radioactive materials on the growth of crop plants. The numerous experiments carried on in Europe and America in an attempt to ascertain the influence of radioactivity on plant growth have produced both conflicting and inconclusive results, and many important questions remain to be answered. In this new cooperative project experiments with radioactive materials will be conducted in both greenhouse and field and on a variety of crops grown on different types of soil. According to the AEC and the USDA, the research getting under way will aim to (1) measure

the effect of additions of radioactive materials to soil and fertilizer on growth, yield, maturity, and composition of certain representative crops; (2) determine the influence of low activities of alpha, beta, and gamma radiation on seed germination and the growth and vigor of seedlings; and (3) discover the influence of radioactive materials on number and activity of bacteria and other soil microorganisms.

WPTZ, the station of the Philco Television Broadcasting Corporation, has been presenting since August 1947 frequent programs direct from the exhibition halls of the Franklin Institute in Philadelphia. These programs have been under the supervision of Roy K. Marshall, director of the Institute's Fels Planetarium and associate director of the Institute's Museum, in charge of astronomy and seismology. As one of the features, a television camera was attached to one of the telescopes of the Observatory of the Institute, and on February 26, for the first time in television history, viewers were able to see the moon as astronomers see it. On March 21, by popular request, a more elaborate program featuring the moon was presented. WPTZ is affiliated with NBC Television, and viewers in New York, Schenectady, Baltimore, and Philadelphia have been able to watch this series of "Living Science."

As a result of these telecasts originating in The Franklin Institute and the public response to programs in science, the station management has arranged for Dr. Marshall to present a weekly telecast called "The Nature of Things," also carried by the NBC Television Network. The popularity of these elementary science demonstrations has been such that a sponsor, the Motorola Company, has made it possible for the program to be presented for an initial period of 26 weeks over the entire NBC network, with additional stations to be added in the near future. The period began April 1.

According to the Philco Television Broadcasting Corporation, "the very first week 'The Nature of Things' was on the air it drew a rating actually higher than three of the five sporting events on the schedule for that week." The program, presented each Thursday at 8:15 P. M., has demonstrated that science, when properly presented, makes good television fare and that television offers to science a new means of reaching the nonscientific public.

Pure unsaturated fatty acids and fatty acid esters are now being manufactured in limited quantity by the Hormel Foundation for distribution to biochemical investigators as a part of a new, nonprofit project initiated at the request of the Hormel Institute of the University of Minnesota. The materials now available are methyl oleate, methyl linoleate, and methyl linolenate, and it is expected that other unsaturated fatty acids and esters will be provided as the program continues. Since it is planned that the project will eventually be self-sustaining, its development and any reduction in prices will depend in large part upon the extent to which the service is utilized. Full descriptive details and prices may be obtained from the Hormel Foundation, Austin, Minnesota.

The British Commonwealth Scientific Office (North America) has announced a change in the post of technical assistant to the director of the United Kingdom Scientific Mission. Mrs. Vera Connell returned to Great Britain on January 23 and is now associated with the British Commonwealth Scientific Office in London. Mrs. Connell, whose chief interests were chemical, had previously been connected with African Explosives and Chemical Industries and the Ministry of Supply in Great Britain. Her place has been taken by Stuart G. Rison, who arrived March 11. Mr. Rison was employed during the war by the Ministry of Aircraft Production and more recently by the Ministry of Supply on radar and electronics work.

The Cooperative Test in Biochemistry is now available to instructors of biological or physiological chemistry. Prepared by the Subcommittee on Biochemistry of the Committee on Examinations and Tests of the Division of Chemical Education, American Chemical Society, with the technical assistance of the Educational Testing Service, the test is designed for both one- and two-semester courses, being composed of validated questions of graded difficulty which sample all topics usually included in fundamental courses in biochemistry. Since national norms are available, students may thus be evaluated in terms of national percentile ratings as well as achievement in a given class. Copies can be purchased in lots of 25 at $2.00 per package from the Educational Testing Service, 15 Amsterdam Avenue, New York City 23.

The National Registry of Rare Chemicals, 35 West 33rd Street, Chicago 16, Illinois, has submitted its latest list of wanted chemicals. It is as follows: dihydrodypnone, auxin A, auxin B, methionic acid, 2-aminooxazole, 4-nonenoic acid, 2-bromo-4-butylglutaric acid, cyclooctatetraene, 1-chlorobutene-2, urobilin, bromogermane, chlorogermane, diallyldichlorosilane, vinyltrichlorosilane, benzylpyrroles, benzylisoxazoles, *l*-glucose, altrose, erythrose, and furfuryl chloride.

Make Plans for—

American Mathematical Society, April 16–17, New York City and Ann Arbor, Michigan; April 17, Berkeley, California.

Association of Southeastern Biologists and **Botanical Society of America**, Southeastern Section, annual spring meeting, April 16–17, University of Florida, Gainesville, Florida.

American Chemical Society, 113th national meeting, April 19–23, Chicago, Illinois.

American Philosophical Society, April 22–24, 104 South Fifth Street, Philadelphia, Pennsylvania.

American Neurological Association, June 14–16, Claridge Hotel, Atlantic City, New Jersey.

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AAAS
Centennial Celebration
Washington, D. C.
September 13–17, 1948

★

Comments and Communications

Hydrolysis of Steroid Esters on Activated Alumina

R. H. Levin, *et al.*, in a paper read before the meeting of the American Chemical Society, held in New York City on September 17, 1947, described the deformylation of the 3-formoxide derivatives of steroids when chromatographed on activated alumina (Fisher). This appears to be a special case of a more general hydrolytic splitting undergone by 3-hydroxy-steroid esters when passed through activated alumina.

A report from this laboratory (W. Dasler and C. D. Bauer. *J. biol. Chem.*, 1947, **167**, 581) has previously pointed out that steroid-3,5-dinitrobenzoates are partially hydrolyzed when chromatographed on activated alumina (Alorco). Thus, free calciferol could invariably be isolated from the eluates of alumina columns upon which calciferyl-3,5-dinitrobenzoate had been adsorbed.

W. C. Hess (*J. lab. clin. Med.*, 1947, **32**, 1163) has reported that when known mixtures of cholesterol and cholesteryl stearate were chromatographed on alumina (according to Brockman, Merck) prior to analysis, the values for free cholesterol tended to be about 5% high, and those for esterified cholesterol, about 5% low. Although other explanations can be advanced to account for these results, it seems not unlikely that this may be another instance of the same phenomenon, viz., the hydrolytic splitting of the steroid ester by the adsorbent.

It seems likely that partial hydrolysis of steroid esters during chromatography has been frequently encountered without being recognized. Some of our more recent work seems to indicate that the *p*-phenylazobenzoates of sterols are more resistant to hydrolysis than some of the other esters when chromatographed on activated alumina.

The hydrolytic splitting of 3-formoxide derivatives of steroids reported by Levin, *et al.* is noteworthy in that the deformylation in the 3- position was apparently complete, whereas formoxide residues at other positions in the molecule were unaffected.

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Crayfish in Southern Nevada

Faxon (*Mem. Mus. comp. Zool.*, 1885, **10**(4), 178), in his Revision of the Astacidae, stated that "the genus *Cambarus* [=Cambarinae] ranges from Lake Winnipeg to Cuba and Guatemala, from New Brunswick to Wyoming Territory (in Mexico to the Pacific Ocean)." Since that time there have been, to our knowledge, no published records which extend appreciably the known range of the Cambarinae. In the United States the most western records are those from Texas, New Mexico, Colorado, and Wyoming [*Procambarus simulans* (Faxon) from Mexico and Chaves Counties, New Mexico, and Boulder County, Colorado; *P. clarkii* (Girard) from Kinney County, Texas; and *Orconectes virilis* (Hagen) from Laramie County, Wyoming].

In August 1944 the junior author collected several crayfish in the Las Vegas River at Las Vegas, Nevada, and forwarded them to the senior author for identification. Upon comparing these with specimens of *Procambarus clarkii* from Texas and Louisiana we find that none of the variations exhibited are greater than those present in a single collection of this species from any given locality in either of these states.

It seems improbable that this species has arrived in the Las Vegas River by normal migration; however, all attempts to find out when and by whom it was introduced have proved futile.

Several years ago Waldo L. Schmitt, of the U. S. National Museum, informed us that *P. clarkii* had been introduced with success in the Santa Rosa, California, region, and we strongly suspect that their presence in the Las Vegas River in numbers may be explained by their finding here, after introduction, another congenial habitat.

It is hoped that we will be able to determine if and when crayfish were introduced in the Las Vegas River.

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The Effect of Rutin on Anaphylactic and Histamine Shock

Raiman, Later, and Necheles (*Science*, October 17, 1947, p. 368) have reported that rutin, a flavonol derivative, protected guinea pigs from anaphylactic shock, but afforded no protection against histamine shock. These authors concluded, therefore, that liberated histamine is not the direct cause of anaphylactic shock, or that rutin prevents liberation of histamine rather than protecting the sensitized animal against liberated histamine.

These conclusions would not be justified if it could be shown that flavonols or their derivatives protect against histamine shock. Such evidence was presented earlier in 1947 by Wilson, Mortarotti, and DeEds (*J. Pharm. exp. Therap.*, 1947, **90**, 120), who showed that under carefully controlled conditions rutin had a slight, though definite, protective action against histamine shock. Still earlier, Parrot and Richet (*C. R. Soc. Biol. Paris*, 1945, **139**, 1072) published data showing that death from histamine could be prevented by compounds closely related to flavonols. These authors demonstrated an increased sensitivity to histamine in scorbutic guinea pigs and reported that administration of a mixture of *d*-catechin isomers counteracted this increased sensitivity.

To permit demonstration of the protective action of rutin we found that the amount of intravenously injected histamine was critical. An approximately LD_{50} dose of 0.25 mg of histamine base/kg of body weight proved to be satisfactory. Raiman, Later, and Necheles used a mini-

mal lethal dose of histamine which they did not define in terms of milligrams per kilogram of body weight, but which killed all of their control animals. Under these conditions a protective action of rutin against histamine could not have been demonstrated if their animals, in other respects, were comparable to ours. The dose of rutin which they administered was considerably smaller than that used by us. However, in our study, variation in rutin dosage was not attempted, and a smaller dose might have protected the animals as well as the amount actually used.

Raiman, *et al.* stated that one animal, given rutin 1 hr before the shocking dose of serum, was not protected. This is not surprising, although it is only a single example. We demonstrated that 10 mg of rutin/animal was not sufficient to protect against histamine shock if the rutin was given an hour before the histamine. It might be expected, therefore, that 2 mg/animal would prove to be infective after this length of time.

Although we believe that rutin acts in an indirect manner and is therefore not a true antihistamine drug, it does protect against histamine shock. The evidence given by Hiramatsu (*Jap. J. Derm. Urol.*, 1941, 49, 304) and by Raiman, Later, and Necheles indicates that it also protects against anaphylactic shock and strengthens, rather than weakens, the theory that the symptoms of anaphylaxis are produced by liberated histamine. Neither the contrary thesis suggested by Raiman, *et al.* nor their alternative that rutin prevents liberation of histamine by the antigen receives any support from the above-mentioned findings. The close relationship of histamine to anaphylactic shock is well illustrated by the following statement from a recent review of antihistamine compounds by Loew (*Physiol. Rev.*, 1947, 27, 562): "All antihistamine drugs which so effectively antagonize the bronchioconstrictive action of histamine are capable of diminishing the severity of anaphylaxis in the guinea pig, in which animal bronchioconstriction is the prominent feature of anaphylaxis."

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The Geological Society of America: A Proposed Section on Geomorphology and Glacial Geology

On December 31, 1947, at Chateau Laurier, Ottawa, about 35 fellows of the Geological Society of America met to discuss the desirability of organizing a Section on Geomorphology and Glacial Geology within the structure of the Society. It was voted that membership of the Society be informed of this proposal, their opinions canvassed, and the results published in the Interim Proceedings of the Society.

The proposed Section would promote the development of geomorphology and glacial geology through the organization of technical sessions and symposia at the Society's meetings. The Section might engage in such other functions as criticism of geomorphic manuscripts submitted to the Society for publication, establishment and operation of a journal or bulletin, encouragement and support of research projects, development of professional opportunities in applied geomorphology, preparation of a directory of geomorphologists, and the translation of important foreign papers.

Arthur N. Strahler, of Columbia University, was given the responsibility of canvassing fellows and members of the Society, to determine their reaction to the organization of such a section. In addition, a committee consisting of M. M. Leighton, Illinois State Geologist, chairman, and Drs. Strahler and Koons was appointed to cooperate with the secretary of the Society in arranging a program dealing with geomorphology, Pleistocene geology, and related subjects at the New York meeting in November 1948.

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FIAT Review of German Science

The readers of *Science* will be interested to know that the first volumes of the FIAT Review of German Science, 1939–1946, have begun to appear. According to T. W. Schaeffer, of the Research Control Branch, Office of Military Government for Wuerttemberg-Baden, the following volumes have already appeared and are distributed by the Office of Technical Services in the Department of Commerce according to recommendations of the Library of Congress: *Biochemistry*, Vol. I (three more volumes to appear, edited by Richard Kuhn); *Physics of solids*, Vol. I (one more volume to appear, edited by G. Joos); *Radiology* (diagnostic and therapeutic), H. Holthusen; *Bacteriology and immunology*, H. Schmidt; *Virus diseases of man*, R. Bieling and H. Heinlein; and *Anatomy, histology, and embryology*, P. Stöhr.

The whole project is to contain 16 volumes of physics, 24 of chemistry, 7 of mathematics, 27 of different branches of medicine, 4 of biology, and 8 of science of the earth. However, according to latest news there are financial difficulties for the military government in bringing this work to conclusion. Moreover, an edition identical with that edited by the military government is in preparation under German auspices. This is to appear under the title *Naturforschung und Medizin in Deutschland, 1939–1946*, and, so far as possible, will be printed from the same plates. (The same volumes of this edition have already appeared as in the allied edition.)

Judging from the volume on biochemistry, which the writer has received, it would seem desirable that efforts to publish at least the larger part of the manuscripts should be continued. The material published in this volume was only in part printed in German science journals during the war; a great deal is new. This volume contains reviews on fat and fat metabolism, by K. Thomas and G. Weitzel, and on inert soaps, by D. Jerchel; four different chapters on natural pigments, mostly from the school of the late Hans Fischer, including posthumous material; and three original papers from O. Warburg, nearly identical with those published in his recent book, *Heavy metals as active groups of enzymes.*

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TECHNICAL PAPERS

Physical State of Lipids and Foreign Substances Producing Atherosclerosis[1]

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In toxicopathological studies on polyvinyl alcohol, methyl cellulose, pure citrus pectin, and gum acacia, Hueper found that repeated intravenous injections of aqueous solutions of these substances resulted in their gradual accumulation in the arterial intima of experimental animals (dogs, rabbits, rats) (*2*). These lesions were of special significance because their morphological appearance and distribution were typically those of atherosclerosis, except that the deposits were of the injected foreign substance instead of lipid. Histological examination revealed 'foam cells' (phagocytes filled with the injected material), hyperplasia of cellular elements, etc. Deposits were also found in reticuloendothelial cells elsewhere. Hueper has expressed the opinion that these substances form a film at the plasma-endothelium interface, produce anoxia of the intima, and thereby cause these pathological changes in the intima. Because these substances are polymers of high molecular weight, he has referred to the lesions as experimental "macromolecular atherosclerosis." These foreign, colloidal compounds, which are stable and quite inert chemically, are of particular interest because of this atherosclerotic-like reaction of the arterial intima to their presence in the circulating blood and body fluids. In contrast, many other foreign substances (*i.e.* drugs) may be maintained at significant blood levels for prolonged periods without any deposition whatever in the arterial intima.

In a recent report (*3*) from this laboratory we presented observations on the physical state and particle size of the plasma lipids in sustained hyperlipemia of metabolic and experimental origin. It was shown that the lipid particles in the plasma in these known causative conditions of atherosclerosis are so large as to be readily visible in the dark-field microscope and are readily separated to the top in a definite lipid layer by moderate centrifugation, in contrast to normal plasma, wherein most of the lipid is stabilized in colloidal particles too small to be seen by dark-field illumination and not separated even by relatively high-speed centrifugation. Primarily, it was shown that the lipid particles (*chylomicrons*) appearing in normal plasma during alimentary hyperlipemia are also of large colloidal size, directly visible in the dark field and readily separated by centrifugation, and contain cholesterol, thus duplicating the coarse particulate distribution of lipids as found in sustained hyperlipemia. From these observations, coupled with clues from the characteristic histogenesis of the lesion, the theory was put forth that the cumulative effect of many fatty meals over a lifetime, by producing these transient showers of large lipid particles in the plasma, is the underlying cause of atherosclerosis in normal humans.

From the above considerations it seemed that similar observations on the particle size of these foreign substances which have been found to deposit in the arterial intima would be pertinent in the evaluation of this chylomicron theory of atherosclerosis. We therefore undertook the simple comparison of the physical state of these injected foreign substances with the lipids in sustained hyperlipemia, alimentary hyperlipemia, and normal blood.

(1) *Small (invisible) colloids or molecules*: (a) *Normal blood serum, fasting or after a nonfatty meal,* contains very few particles of sufficient size to be visible in the dark field. These appear as tiny, dancing specks and are for the most part at the extreme lower limits of detection by this method. High-speed centrifugation (22,500 × G for 1 hr) produced no observable separation of lipid particles to the top (in contrast to hyperlipemic serum). Ultracentrifuge studies on plasma proteins have indicated that with many times greater centrifugal forces much of the lipid in normal, fasting serum is sedimented to the bottom in protein-bound molecular complexes (*5*). The magnitude of the necessary centrifugal forces, the paucity of visible particles by dark field, and the clearly transparent appearance attest the high degree of dispersion and stabilization of the lipids intrinsic in normal plasma. We believe that deposition of lipid particles in the arterial intima does not occur under these conditions. (b) *Drugs, foreign substances* such as salicylates, barbiturates, sulfonamides, and others that form true solutions in water, are carried in molecular size far smaller than can be detected in the dark field, exhibit no demonstrable Tyndall effect, and are not separated from water or blood plasma by high-speed centrifugation. These molecularly dispersed foreign substances are not deposited in the arterial intima.

(2) *Large colloidal particles (colloidal suspensoids)*: (a) *Sustained hyperlipemia*: By dark-field illumination hundreds of large and easily visible particles are observed in each high-power field (*3*). This plasma is grossly milky or creamy by transmitted light and presents marked Tyndall effect by incident light. Centrifugation at 3,000–5,000 × G for 1 hr usually separates major portions of the lipid particles to the top. Centrifuging at 15,000–20,000 × G brings up all large lipid particles in a solid lipid layer

[1] The author is indebted to L. G. Moench, of the University of Utah Medical School and the Salt Lake Clinic, for his valuable criticism of these studies; to G. H. Joseph, of the California Fruit Growers Exchange, for pure citrus pectin; to R. M. Upright, of the Dow Chemical Company, for methyl cellulose; and to J. F. Davis, of E. I. du Pont de Nemours, and Company, for polyvinyl alcohol.

on top of a now clear, *infra*natant plasma. Sustained hyperlipemia in man or experimental animals is known to result in the relatively rapid and severe development of lipid deposition in the arterial intima. (b) *Alimentary hyperlipemia*: The digestion and absorption of a fatty meal causes, for 3–5 hrs, the appearance of large and visible particles in the plasma of normal subjects. The plasma is grossly milky and exhibits marked Tyndall effect. This *hyper-* and *macrochylomicronemia* is indistinguishable from sustained hyperlipemia in dark-field appearance and in behavior in the high-speed centrifuge, and thus temporarily duplicates that physical state of the lipids which has been found to be characteristic of the known causative conditions of atherosclerosis (*3*). We contend that in normal humans deposition of lipid and atheromagenesis occur only during, and as a result of, the chylomicronemia produced by the ingestion of a fat-rich meal. (c) *Polyvinyl alcohol, methyl cellulose, pectin, gum acacia*: Dark-field study of each of these substances in aqueous solutions revealed that they are carried, not in 'true solution' or invisible colloidal dispersion, but in colloidal suspensions of many large and visible particles, the major portions of which are identical with chylomicrons in particle sizes. (Large particles were not as numerous in gum acacia solutions as in solutions of the other substances of the same concentration.) By stepwise increasing the centrifugal force in the high-speed centrifuge, it was grossly observed that the energies necessary to bring most of the lipid particles to the top in sustained or alimentary hyperlipemia were of comparable magnitude to energies necessary to sediment the greater part of these experimental substances to the bottom, providing further evidence of the similarity in particle size ranges (Stoke's law). The amount of sedimentation produced at different speeds was observed to be the same whether these substances were suspended in water or blood plasma, thus indicating that no change in physical state or particle size of these inert substances occurs as a result of admixture with plasma. From these observations it would seem justifiable to conclude that the large size of the colloidal particles in which these injected substances are carried is the cause of their deposition and retention from the plasma-derived nutrient lymph normally entering and passing through the arterial intima and is the stimulus to their phagocytosis and formation of the typical foam cells.

In a report concerning pellagrous South African natives, Gillman and co-workers (*1*) have related the large size of certain pathological iron-pigment molecules in the plasma with the cause of their deposition in the arterial intima and reticuloendothelial cells elsewhere (*cytosiderosis*). This observation adds support to the premise that the physical size of the colloids in plasma is the determining factor in their deposition in the arterial intima.

The above evidence is here put forth in confirmation of the *hyper-* and *macrochylomicronemia* theory of atherosclerosis (*3*). It is apparent that those large lipid particles which pass with the lymph into the intima incite the foreign-body response which is a characteristic histological feature of the origin and development of atherosclerosis. Triglycerides and fatty acids are rapidly resorbed from the depositing mixed-lipid particles. Cholesterol, which is difficult to resorb and remove, remains and accumulates as the predominant residue in the slowly developing lesion (*3, 4*). Lipid particles which contain larger percentages of cholesterol, as in sustained hyperlipemia (hypercholesterolemia), leave a greater residue and build up lesions more rapidly than lipid particles which contain smaller percentages of cholesterol (i.e. chylomicrons) (*4*). When this residue of inert and difficult-to-resorb cholesterol is thus trapped between the high-pressure blood column on one side and the internal elastic membrane on the other, it is withheld and prevented from being dispatched to the liver (and possibly other sites), where theoretically it could be relatively easily degraded or eliminated by cells that are specialized in such metabolic functions. Thus, the accumulation of lipids in the arterial intima seems to be a local, mechanical problem, and unrelated to general body balance or over-all metabolism of these substances.

It appears that the primary factor and *sine qua non* in atherosclerosis is the presence in the circulating blood of coarsely suspended colloidal particles considerably larger than those found in normal plasma and composed of, or containing, a substance relatively resistant to the resorptive and removal mechanisms of the arterial intima (macrophages and tissue fluid enzymes). It would seem that local intimal permeability and intravascular pressure are secondary factors that determine the local influx of plasma-derived nutrient lymph and thus determine the local distribution of the lesions in the vascular tree. Increased local permeability (rheumatic and syphilitic arteritis, etc.), or hypertension, may produce increased deposition, but only during periods when *hyper-* and *macrochylomicronemia* exists. The postprandial period following a fat-rich meal is the only time the plasma of normal individuals carries large amounts of coarsely particulate matter. Atherosclerosis, then, is the result of the fact that (a) oil and water do not mix, and therefore fats and oils in blood plasma must be carried in molecular complexes or stabilized colloidal particles; (b) fats entering the circulation from the intestine are absorbed and carried, not in the same finely divided state as the intrinsic lipids of the plasma, but in much larger particles of varying sizes; (c) the primitive scavenger and phagocytic function of reticuloendothelial cells in the arterial intima, plus the barrier action of the internal elastic membrane, are the responsible functional components of the mechanism of deposition and actual retention of those large particles that happen to be forced into the intimal tissue spaces with the plasma-derived nutrient lymph. Molecular substances and the finely dispersed normal plasma lipids and proteins pass through the arterial intima without being retained and deposited therein. In contrast, the large lipid particles in sustained or alimentary hyperlipemia, and the coarsely suspended foreign substances above described, are treated as particulate foreign bodies and are arrested, phagocytosed, and entrapped in the arterial intima. In conclusion, present evidence indicates that the ingestion of fat-rich meals,

by producing the temporary appearance of large lipid particles in the blood, causes the normal defense mechanisms of the intima to retain some of these particles and thus gradually and infinitesimally to build up the full picture of stenotic and occlusive arterial disease.

The pathogenic mechanism and etiology of atherosclerosis will be considered in greater detail in other communications from this laboratory.

References

1. GILLMAN, J., GILLMAN, T., MANDELSTAM, J., and GILBERT, C. *Nature, Lond.*, 1947, **159**, 875.
2. HUEPER, W. C. *Arch. Path.*, 1939, **28**, 510; 1945, **39**, 117.
3. MORETON, J. R. *Science*, 1947, **106**, 190.
4. MORETON, J. R. (To be published.)
5. PEDERSON, K. O. *Ultracentrifugal studies on serum and serum fractions.* Upsala: Almqvist and Wiksells Boktryckeri, 1945.

The Production of Mushroom Mycelium (*Agaricus campestris*) in Submerged Culture

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Commercial mushroom production in the United States is accomplished exclusively by growing the mushroom, *Agaricus campestris*, on composts, usually prepared from horse manure. The purpose of this paper is to present the first instance in which the mycelium of this mushroom has been grown on liquid medium under submerged fermentation.

Since the mycelium produced by this technique was obtained in good yield and was found to have the characteristic mushroom flavor, it seems possible that production in submerged culture will have considerable application in the manufacture of mushroom soups, gravies, and flavorings and in the production of spawn for seeding commercial mushroom beds.

For the preliminary tests, a strain of *A. campestris* was isolated from a white mushroom of this species taken from a commercial mushroom bed. A good growth of mycelium was obtained on wort agar. The mycelial mat was broken up in a sterile Waring blendor, and a sterile culture medium was inoculated with the suspension. The inoculated medium was then transferred to the fermentor and incubated at 25° C until a heavy growth of finely divided hyphae had been obtained. For tests on a small scale the fermentor equipped for rapid agitation during aeration and described by Feustel and Humfeld (*1*) was used, while for production in larger amounts the fermentor designed to draw in air by suction during agitation as described by Humfeld (*2*) was employed.

Good growth of mushroom mycelium was obtained on media containing either asparagus butt juice or press juice from pear waste as the main substrate. The addition of inorganic salts was essential in the pear juice medium. It was also found that fair yields could be obtained in media consisting of monosodium glutamate, dextrose, and inorganic salts.

After the culture was harvested, the mycelium was separated from the culture liquor by centrifuging. The mycelium was resuspended in water and recentrifuged. The samples made up in the preliminary work were dried from the frozen state.

Yields of mycelium up to 60% by weight of the sugar consumed have been obtained. The growth from a comparatively small inoculum is rather slow as compared to that of yeast; however, a continuous-fermentation experiment indicated that, once the maximum cell volume consistent with the composition of the medium has been attained, from one-half to three-quarters of the culture medium may be harvested and replaced with fresh sterile medium every 6–12 hrs of operation. Successful operation by this method has been accomplished over a period of 6 consecutive days. For instance, in one experiment, 3.75 liters of culture medium, which contained 20 gm of mycelium on the dry basis, was built up in 33 hrs to a volume of 16 liters with a dry weight of mycelium of 421 gm. At this stage 8 liters of the culture was harvested and 8 liters of fresh medium added to the 8 liters remaining in the fermentor. Maximum cell volume was attained in 12 hrs. This procedure was repeated, and there was no indication that such operation could not be continued indefinitely. This and other experiments indicate that no serious difficulties should be encountered in adapting the process to economic commercial production of mushroom mycelium.

The chemical compositions of commercial mushrooms and the mushroom mycelium produced by submerged fermentation were found to be very similar. McConnell and Esselen (*3*) report that *A. campestris* mushroom contains protein (N × 6.25), 35.6%; fat (ether-soluble material), 2.3%; and ash, 10.2%, calculated to a moisture-free basis. The mushroom mycelium produced by submerged fermentation, calculated to the same basis, contained protein, 49.1%; fat, 3.1%; and ash, 8.1%. It may be noted that the mycelium was somewhat higher in protein and fat content, and lower in ash. Other constituents such as carbohydrates and fiber have not been determined.

The adaptation of the submerged-culture process to the production of mycelium of the higher fungi would seem to offer the possibility of industrial-scale application to an extensive group of organisms. Such application may include the production of enzymes such as cellulase, solvents, antibiotic agents, and substances of pharmaceutical significance. Each species would probably need considerable investigation to determine optimal conditions for its propagation and for the production of such desired substances.

References

1. FEUSTEL, I. C., and HUMFELD, HARRY. *J. Bact.*, 1946, **52**, 229–235.
2. HUMFELD, HARRY. *J. Bact.*, 1947, **54**, 689–696.
3. MCCONNELL, J. E. W., and ESSELEN, W. B., JR. *Food Res.*, 1947, **12**, 118–121.

Heterologous Tumor Transplantation by Intravenous Inoculation of the Chick Embryo[1]

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In general, tissue transplanted from one species to another fails to grow. Whether donor tissue is normal or neoplastic, the antagonistic response of the recipient usually precludes survival of heterologous transplants.

Explantation of tumor tissue with survival for varying periods has been accomplished by tissue culture technics; by inoculation of neoplastic cells into the anterior chamber of the guinea pig or rabbit eye; and by inoculation of such cells onto the chorioallantoic membrane or into the yolk sac of the chick embryo.

There is no evidence to indicate that the chick embryo forms antibodies before the 18th day of incubation. The fact that many types of tissue from various sources have been grown for short periods on the chorioallantoic membrane may well be related to the absence of antibody formation.

Previous experience (*1*) with intravenous inoculation of chick embryos with suspensions of *Myco. tuberculosis* suggested that this method might be useful in establishing heterologous tumor growth within the embryo.

Sterile tumor tissue was obtained from patients at operation, from tumor-bearing rats and mice, and from tissue culture. The tumor tissue was collected under aseptic precautions and placed in sterile physiological saline solution. It was then forced through a 70-mesh Monel wire screen and a cell suspension prepared in physiological saline solution. It has been determined previously that cell suspensions produced in this manner contain viable tumor cells (*2*).

Chick embryos incubated for 11 days were prepared for intravenous injection by removal of the shell over the air sac and exposure of the allantoic veins by reflection of a portion of the shell membrane. The technic has been reported previously in detail (*1*). An inoculum of 0.05 cc of cell suspension was injected intravenously into each embryo. A total of 278 embryos were injected in a series of 17 experiments. Approximately 50% of the embryos survived and were opened for examination on the 20th day of incubation.

In the experiments in which human tumor tissue was used there were 4 embryos (10% of survivors) which showed tumor "takes" upon histologic examination. The transplantation of the C57 strain mouse sarcoma (#241) was more successful. Twenty per cent of surviving embryos injected with a cell suspension prepared from this mouse sarcoma have shown tumor growth. In the entire series of experiments there was evidence of tumor growth in the brain or liver of 13% of surviving embryos.

The neoplastic cells maintained their histologic character in the embryo and closely resembled the parent tumors. This morphologic evidence suggests the probable identity of the transplants with the parent tumors.

[1] This work was carried out in the laboratories provided by the Henry Phipps Institute of the University of Pennsylvania. Equipment was supplied by the Heyden Chemical Corporation.

References

1. LEE, H. F., STAVITSKY, A. B., and LEE, M. P. *Proc. Soc. exp. Biol. Med.*, 1946, **61**, 143; *Amer. Rev. Tubere.*, 1947, **55**, 262.
2. LEWIS, M. R. Personal communication.

Diffuse and Nodular Hyperplasia of the Thyroid Gland in Thiouracil-treated Rats[1]

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In 1927, Wegelin (*10*) reported thyroid adenomata in rats on stock and experimental diets in endemic goiter regions in Switzerland and observed a malignant spindle-cell sarcoma of the thyroid with metastases to the lungs, myocardium, and pericardium in an old rat. The occurrence of adenomata in the thyroid glands of aged rats has been infrequently reported (*3, 6, 8, 9, 10*). Hellwig (*5*) observed thyroid adenomata in albino rats receiving a calcium-rich goitrogenic diet for 140 days. Bielschowsky (*1*) produced benign and malignant tumors of the thyroid in rats by the simultaneous or successive administration of 2-acetyl-amino-fluorene and allyl-thiourea for long periods of time; however, neither drug alone produced neoplastic growths in the thyroids. Griesbach, Kennedy, and Purves (*4*) noted that diets containing 45% *Brassica* seeds could produce multiple thyroid adenomata in rats and that the seeds contained chemical substances related to thiouracil and sulfonamides. Purves and Griesbach (*7*) observed adenomata of the thyroid gland in a high percentage of animals treated with thiourea for 12 months or more, and such neoplasms had a tendency to become malignant when the administration of thiourea was extended to 20 months or longer. In two animals with malignant tumors metastases to the lungs were observed. Donald and Dunlop (*2*) reported "extreme parenchymatous hyperplasia and an almost complete absence of colloid" in a patient given thiouracil for 5 months.

The purpose of our report is to indicate the high incidence of diffuse and nodular hyperplasia of the thyroid gland induced by prolonged administration of thiouracil. This is a part of a general study showing that thiouracil-induced hypothyroidism is accompanied by increased severity in rat polyarthritis induced by pleuropneumonia-like organisms (L_4 strain). The details of this study will be reported separately.

[1] This work was done under contract with the Office of Naval Research.

Albino rats weighing approximately 100 gm. were grouped according to sex and placed on a diet containing

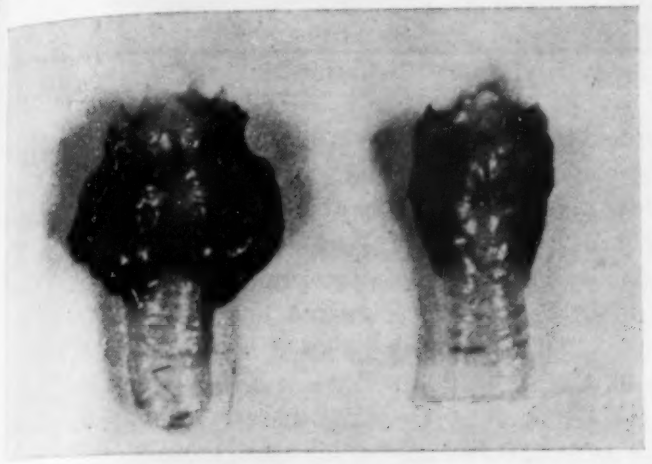

FIG. 1. **Marked thyroid hypertrophy (left) in a thiouracil-medicated rat compared with the thyroid (right) of a control unmedicated rat.**

0.1% thiouracil. The diet was prepared by grinding the thiouracil in a mortar and blending it for 30 min in a mechanical mixer with the basic diet of ground Purina Dog Checkers. Control animals received the basic diet. All animals were permitted unrestricted access to both food and water.

Since this experiment was designed to determine the effects of induced hypothyroidism on the course of experimental polyarthritis in rats, all animals were inoculated intraperitoneally after varying periods of time (34, 51, or 85 days, respectively) with 2 ml of an 18-hr broth culture of the L_4 strain of pleuropneumonia-like organisms. In some experiments, the basic diet was substituted for the thiouracil diet at the time of inoculation.

At the end of the experimental period the animals were killed, and their thyroid glands weighed and examined histologically. The extreme thyroid gland hypertrophy in those animals which had received thiouracil for long periods of time was evident on gross inspection (Fig. 1), and this was further substantiated by the gland weights. The results are presented in Table 1, in which the animals are grouped according to the total experimental period and the time they were on the thiouracil diet. There was no evidence that the time of inoculation or infection of the microorganisms had any effect on the thyroid gland.

Histologically, the thyroid glands from animals which had received no thiouracil were normal. Glands of those animals which were removed from the thiouracil diet after 34 or 51 days and placed on the control diet failed to show hyperplastic changes. The thyroid glands from all animals on the thiouracil diets for 120 days or longer were distinctly hyperplastic with areas of nodular hyperplasia. In animals which had received thiouracil for 120 and 142 days, the numbers of discrete hyperplastic nodules were 2 and 3, respectively. Fifteen nodules were found in the thyroids of 7 of the 24 animals which had received thiouracil for 233 days. These areas of nodular hyperplasia were occasionally demarcated from the adjacent hyperplastic thyroid parenchyma by a zone of condensed fibrous tissue. The thyroid epithelium within the areas of nodular hyperplasia was distinctly different from the adjacent tissue in that the cells were high cuboidal rather than columnar and the nuclei less vesicular and more deeply stained with nuclear stains. Colloid with peripheral vacuoles frequently filled the acini.

From these experiments it is concluded that thiouracil, administered to normal albino rats for prolonged periods of time, induces diffuse and nodular hyperplasia of the thyroid gland. The frequency of nodular hyperplasia is related to the total amount of thiouracil ingested.

TABLE 1

INFLUENCE OF THIOURACIL ON WEIGHT OF THE RAT THYROID

Total experimental period (days)	Thiouracil medication (days)	Females			Males		
		No. of animals	Avg. wt. of thyroid (mg/100 gm body wt.)	Increase above normal wt. (%)	No. of animals	Avg. wt. of thyroid (mg/100 gm body wt.)	Increase above normal wt. (%)
120	0	9	8.3	0	5	8.4	0
	34–51	7	12.5	50.6	4	14.2	69.1
	120	8	31.8	283.	6	39.8	378.
142	0	7	8.2	0	....	....	....
	142	9	33.6	309	....	....	....
233	0	3	8.4	0	3	7.5	0
	233	13	49.3	487	11	44.2	489.3

References

1. BIELSCHOWSKY, F. *Brit. J. exp. Path.*, 1944, **25**, 1, 90; 1945, **26**, 270.
2. DONALD, J. B., and DUNLOP, D. M. *Brit. med. J.*, 1945, **1**, 117.
3. GAYLORD, H. R. *Sixth annual report, Cancer Laboratory, N. Y. State Department of Health*, 1904–05.
4. GRIESBACH, W. E., KENNEDY, T. H., and PURVES, H. D. *Brit. J. exp. Path.*, 1947, **28**, 18.
5. HELLWIG, C. *Amer. J. Cancer*, 1935, **23**, 550.
6. LOEB, L. *Amer. J. med. Sci.*, 1903, **125**, 873; *Cbl. Bakt.*, 1904, **37**, 235.
7. PURVES, H. D., and GRIESBACH, W. E. *Brit. J. exp. Path.*, 1947, **28**, 46.
8. SLYE, M., HOLMES, H. F., and WELLS, H. G. *J. Cancer Res.*, 1926, **10**, 175.
9. VAN DYKE, J. H. *Anat. Res.*, 1944, **88**, 369.
10. WEGELIN, C. *Schweiz. med. Wschr.*, 1927, **8**, 848.

IN THE LABORATORY

The Use of Glycine in the Disruption of Bacterial Cells[1]

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Following the addition of glycine to a suspension of living bacteria there results an apparent progressive lysis of the cells. This glycine action was reported by one of us (*1*), who, using thin suspensions of bacteria and following the reaction by turbidimetric methods, studied the effect upon the process of varying some of the factors involved. With the intention of developing the procedure into a method by which chemical fractions could be obtained from larger volumes of cells, attempts have been made to define the conditions optimal for the purpose. Among the factors considered which might influence the lytic process are the concentration of glycine, age of the culture, relative proportions of cell volume to solution volume, and length of time required for lysis.

The procedure consisted in suspending packed saline-washed cells, obtained from 2-liter shake cultures of the desired species, in glycine solutions of different concentrations. The weakest solutions used were of 0.5 M concentration, and the strongest, 3 M. All were adjusted to pH 7.5 before the addition of cells. The age of the cultures was varied from 1 to 10 hrs, and the volume ratios of cells to solution from 1:1 up to 1:10. The period of action was from ½ hr to 18 hrs of incubation at 37°. To determine the efficacy of the lytic process, the viscous mixtures were diluted with saline when necessary to facilitate sedimentation and then centrifuged. A 20-min period at 14,000 rpm was usually sufficient to yield a clear supernate. The amount of protein in this, as well as that in the original cell suspension, was determined by adding equal volumes of 10% trichloracetic acid to aliquots containing about 1 mg of protein nitrogen. The precipitated protein was washed repeatedly by mixing with 5% trichloracetic acid, centrifuging, and removing the supernatant fluid by decantation. The final wash solution was tested for the presence of nitrogen. For nitrogen analysis, the washed precipitate was finally dissolved in M sodium hydroxide and transferred to a Kjeldahl flask.

When suspensions of *Escherichia coli*, *Aerobacter aerogenes*, or *Bacillus mesentericus* were treated with glycine, as much as 85% of the cellular proteins could be detected in the clear supernatant fluid after 16 hrs of incubation. It was observed that in that period no increase in the amount of protein extracted was effected by increasing the concentration of glycine beyond 1 M. However, the rate of lysis did appear to be more rapid when the more concentrated solutions were employed. The amount of protein material extracted was found also to be a function of the relative proportion of glycine solution to the volume of cells. A ratio of 1 volume of packed cells to 10 volumes of glycine solution proved convenient and effective, although, if it is desired to keep the volume small, even a 1:1 ratio may be used with a somewhat poorer yield. With the latter, however, considerable dilution with saline must be made to permit sedimentation of the undissolved matter in the centifruge.

When cultures of different age were exposed to 1 M glycine for 18 hrs, the degree of lysis, as represented by the amount of protein present in the supernatant fluid, decreased with the age of the culture. The most complete lysis occurred in cultures from 1 to 3 hrs old. On treatment with 1 M glycine, the supernate of a 3-hr culture of *E. coli* showed an increase in protein content, with time, up to the 6th hr of incubation. No further increments were noted. In all cases, the extraction of large amounts of polysaccharide was noted but not quantitated.

TABLE 1

Treatment	Protein extracted (%)	
	E. coli	*B. mesentericus*
Distilled water, 16 hrs, 37°	8.0	4.0
Saline, 0.85%, 16 hrs, 37°	3.0	3.5
Phosphate buffer, 0.05 M, pH 7.5, 16 hrs, 37°	5.5	5.0
Glycine, 3 M, pH 7.5, 16 hrs, 37°	77.0	82.0
Sonic vibration, 9,000 cycles, 10 min, water, 10°	96.0	93.0

The relative efficiency of several procedures for obtaining cellular proteins was compared and evaluated, as before, by the percentage of protein released from the cell. Table 1 lists the results obtained when equal volumes of cells suspended in equal volumes of fluid were treated as described.

The ease and simplicity of effecting the solution of the intracellular contents of bacteria by means of their disintegration or lysis in the presence of glycine suggests many possible uses for this procedure in the separation or isolation of bacterial proteins, including, perhaps, enzymes, nucleic acids, and polysaccharides. Variations in some details may necessarily have to be made in order to obtain certain specific cellular entities. For example, our own efforts to obtain highly polymerized desoxyribonucleic acid were not always successful. The procedure consisted of deproteinizing the clear, viscous glycine extract or lysate with chloroform and pouring the protein-free solution rapidly into 2 volumes of 95% alcohol. Two types of precipitate were thus obtained, a fibrous product which appeared immediately, and a granular precipitate which came down more slowly. It was pos-

[1] Aided by a grant from the Office of Naval Research.

sible to collect the fibrous material by twirling a wooden applicator stick through the suspension of fibers. The fibers adhered to the stick and could be removed before the bulk of the granular substance came out of solution. This fibrous material consisted of much polysaccharide and some nucleic acid, which was determined by the diphenylamine reaction, the phosphorus, or the purine nitrogen content. Younger cultures proved to be better sources of this material than older ones, in which increased amounts of polysaccharide tended to obscure the relatively small quantities of fibrous nucleic acid present.

With the thought that possibly enzymes simultaneously released from the cells might be acting on the extracted cellular materials, attempts were made to increase the yield of desoxyribonucleic acid by adding citrate or phosphate ions to the glycine solution in order to bind magnesium ions, which presumably activate nucleases or polymerases. Contrary to expectation, the yields were considerably diminished. The failure in this instance merely stresses the point that the extraction of each specific substance poses its own problem.

Reference

1. COWLES, P. B. *Yale J. Biol. Med.*, 1947, **19**, 835–838.

A Pipette for the Rapid Transfer of Measured Quantities of Solution

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Measured quantities of solution are transferred frequently in routine analyses. Rapid measurements with a minimum of equipment are desirable when large numbers of determinations are to be made. This is particularly true in the soil-testing laboratory, where a measured quantity of water is mixed with a measured quantity of soil prior to the determination of the pH of the mixture.

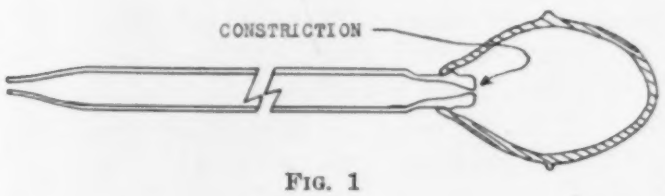

FIG. 1

A rubber bulb attached to a dropping pipette which has been modified by shrinking the upper end to produce an annular constriction with a diameter of about 0.2 mm provides an excellent device for the rapid transfer of liquids (Fig. 1). When water rising in the pipette encounters the constriction, a pronounced click or jerk is produced. The rate of flow of liquid through the constriction is so slow that the pipette may be removed from the liquid with a relatively constant amount of solution. A 200-mm dropping pipette, modified as described above, delivered 5.5 ml with a standard deviation of ±0.02 ml based on 50 determinations. A Mohr pipette, adjusted to deliver 10 ml of liquid when filled to the constriction, delivered 10.01 ml with a standard deviation of ±0.06 ml and a maximum deviation of 0.1 ml.

A Method for the Aeration of Liquid Cultures of Microorganisms

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The devices commonly used for aerating and agitating liquid cultures have been found to be not entirely satisfactory for use in culturing certain bacteria in liquid media. These devices are usually extremely difficult to sterilize and keep physically clean; also, because of the size and number of bubbles produced, they may have a low aerating efficiency.

It has been found that air passing at acoustic velocities through an orifice will produce a large number of

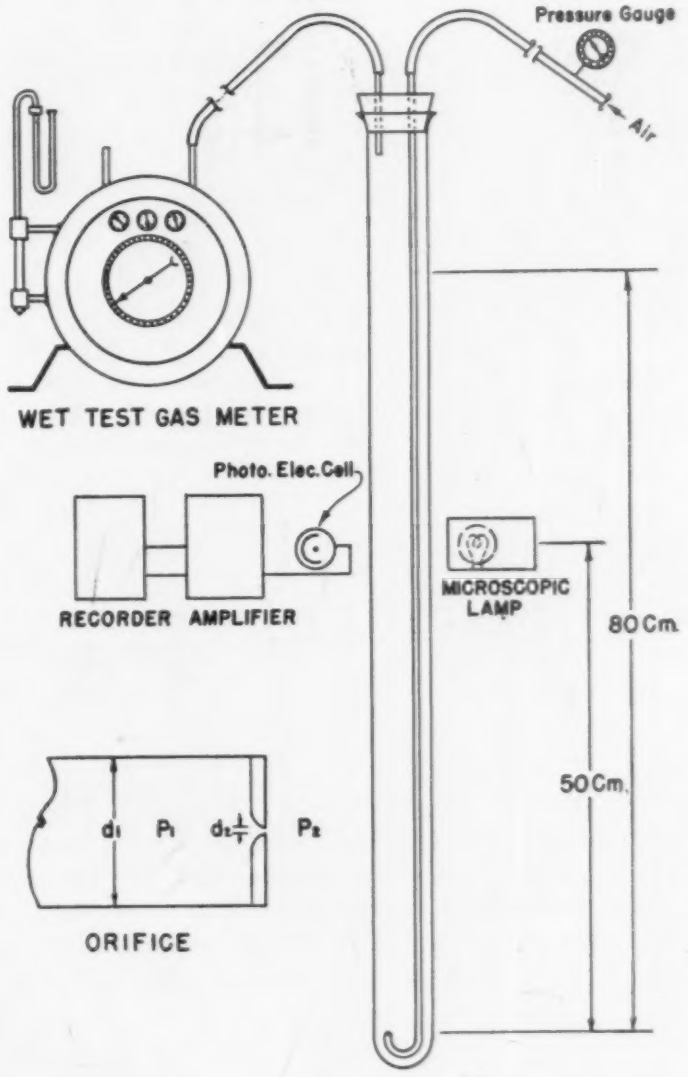

FIG. 1

very small bubbles, many of which are below 10 μ in diameter, and will cause violent agitation of the liquid. This orifice type of sparger was compared with sintered stainless steel, fritted glass, carbon, aloxite, and dishpan type spargers to determine which would produce the highest percentage of small bubbles. This was done by passing an equal amount of air (1 vol of air/vol of liquid/min) through the various types of spargers submerged in 80 cm of a 2% peptone medium contained in a glass tube (8 × 110 cm). The turbidity was measured, as illustrated in Fig. 1, with a continuous turbidimeter at 50 cm above

the sparger discharge. The initial turbidity, as well as the length and slope of the curve, indicate the size, number, and percentage of bubbles of various sizes produced.

As illustrated in Fig. 2, the orifice sparger operated at acoustic velocities produced a larger number of smaller bubbles than the other spargers tested, as evidenced by the initial turbidity and the time required for the medium to clear. This method of aeration will produce many bubbles smaller than 10 μ in diameter as measured by an ocular micrometer. Since the internal pressure of bubbles varies inversely with the diameter in a given liquid, it is highly desirable to obtain the smallest bubbles possible.

Acoustic velocities of air at 15° C are obtained through an orifice when $\frac{A_1}{A_2} > 25$ and when $\frac{P_2}{P_1} < 0.53$ (critical pressure ratio of air at 15° C), where A_2 = area of orifice; A_1 = area of tube; P_1 = upstream pressure (absolute); and P_2 = downstream pressure (absolute). Therefore, an orifice 0.00312″ in diameter would require a minimum tube diameter of 0.156″ and a pressure differential across the orifice of 13 lbs/sq in to pass air (at 15° C) at acoustic velocities.

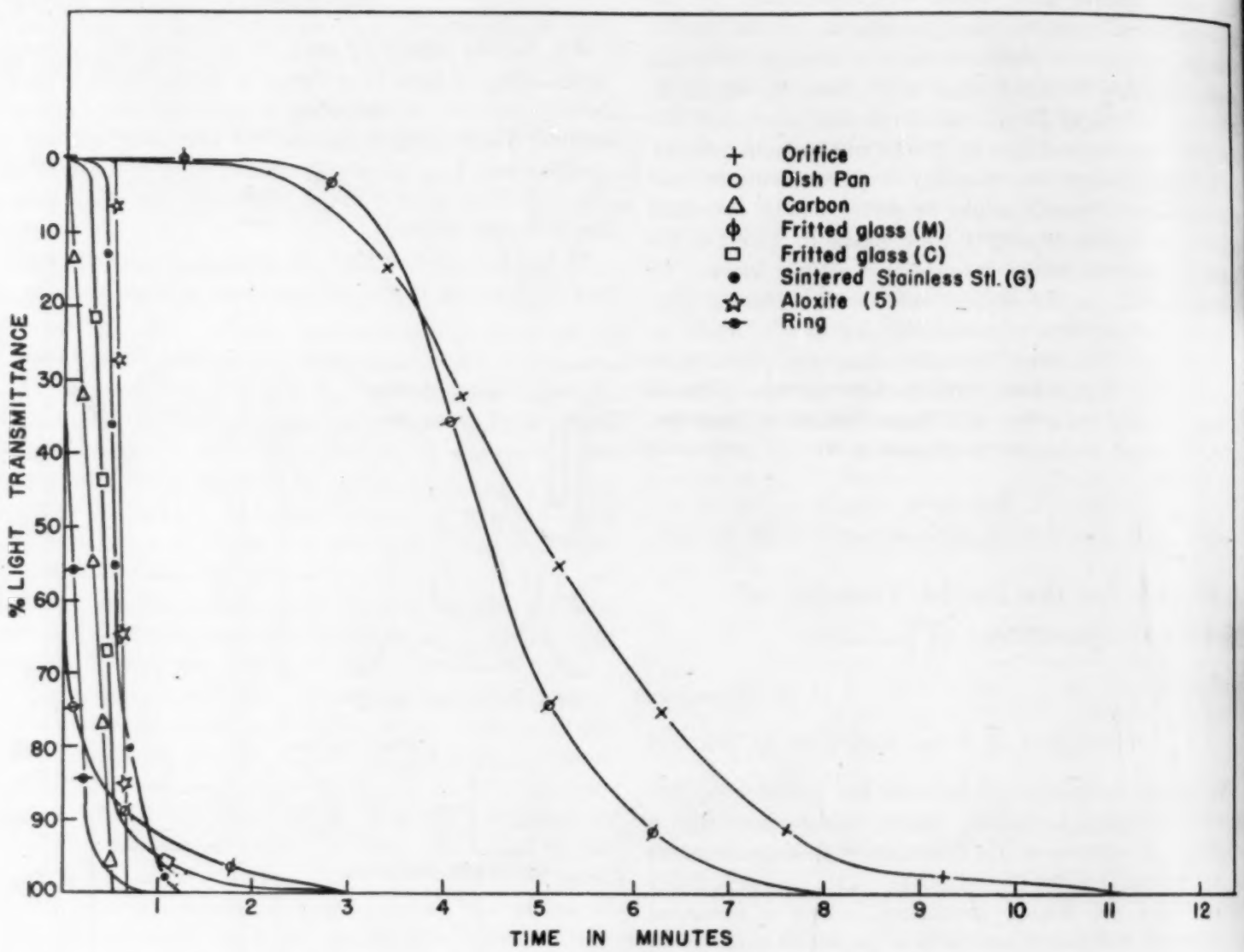

FIG. 2